

ACTIVE READING ON TABLET TEXTBOOKS

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## DEDICATION

*For Jim, Gage & Quinn*

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## ACTIVE READING ON TABLET TEXTBOOKS

To study a text, learners often engage in active reading. Through active reading, learners build an analysis by annotating, outlining, summarizing, reorganizing and synthesizing information. These strategies serve a fundamental meta-cognitive function that allows content to leave strong memory traces and helps learners reflect, understand, and recall information. Textbooks, however, are becoming more complex as new technologies change how they are designed and delivered. Interactive, touch-screen tablets offer multi-touch interaction, annotation features, and multimedia content as a browse-able book. Yet, such tablet textbooks—in spite of their increasing availability in educational settings—have received little empirical scrutiny regarding how they support and engender active reading.

To address this issue, this dissertation reports on a series of studies designed to further our understanding of active reading with tablet textbooks. An exploratory study first examined strategies learners enact when reading and annotating in the tablet environment. Findings indicate learners are often distracted by touch screen mechanics, struggle to effectively annotate information delivered in audiovisuals, and labor to cognitively make connections between annotations and the content/media source from which they originated.

These results inspired SMART Note, a suite of novel multimedia annotation tools for tablet textbooks designed to support active reading by: minimizing interaction mechanics during active reading, providing robust annotation for multimedia, and improving built-in study tools. The system was iteratively developed through several rounds of usability and user experience evaluation. A comparative experiment found that SMART Note outperformed tablet annotation features on the market in terms of supporting learning experience, process, and outcomes.

Together these studies served to extend the active reading framework for tablet textbooks to: (a) recognize the tension between active reading and mechanical interaction; (b) provide designs that facilitate cognitive connections between annotations

and media formats; and (c) offer opportunities for personalization and meaningful reorganization of learning material.

Joseph Defazio, Ph.D., Chair

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## **1 Introduction**

Rapid adoption of tablet devices in educational settings has captured the imaginations of educators, textbook publishers, and technology companies around the world. The rising popularity of tablets in elementary, secondary, and higher education alike has been attributed both to their portability and to the potential for novel teaching and learning tools, not the least of which is the interactive, multimedia textbook. According to a recent Book Industry Study Group report, “the way students learn and instructors teach is undergoing a radical shift, and the role of the traditional print ‘textbook’ as the foundational tool for instruction is changing along with the traditional publishing model” (Vassallo, 2014). Furthermore, with more school districts across the United States launching 1:1 programs in which each student has daily access to his or her own tablet device, the digital textbook market is expected to grow significantly over the next five years (Hoffelder, 2014).

Some of the world’s largest tech companies and book retailers have recently purchased or partnered with up-and-coming digital textbook developers. For example, in early 2014, Intel finalized the acquisition of digital textbook startup Kno to “create an ecosystem of hardware, software and digital content specifically designed to help students learn and to offer educators the tools to effectively integrate technology into the classroom” (Galvin, 2013). Then, in March 2014, Ingram’s VitalSource Technologies acquired CourseSmart in a deal that united two of the largest players in the digital college textbook market (Campbell, 2014). Later that month, Amazon announced a new distribution deal with the Brazilian government to distribute 200 textbook titles to teachers and students across Brazil (Melo, 2014). Finally, Inkling Habitat—the most widely adopted platform to date—partnered with McGraw-Hill Education in 2014 to build the “next-generation learning products and tablet textbooks” (Hebbard, 2014).

These partnerships are important evidence of a growing trend toward digital innovation where textbooks are concerned. Inkling books, for example, boast a number of useful features, including the ability to highlight text, take notes, and explore clickable keywords; bookmark pages and sections of a text; mark helpful notes others have posted in a social learning network; and browse collections of highlighted text, notes, reading history, and glossary terms. Inkling books also allow learners to follow anyone using the

same book, see their notes and highlights, and create running discussions. Clearly, textbooks are becoming more complex as new technologies change how they are designed and delivered. Furthermore, interactive, touch-screen tablets offer multi-touch interaction, annotation features, and multimedia content designed as browse-able books. These features exist to support active reading, a fundamental set of strategies for meaningful learning that has governed educational reading for more than five decades.

Through active reading, learners build an analysis by annotating, outlining, summarizing, reorganizing, and synthesizing information. These strategies serve a fundamental meta-cognitive function that allows content to leave strong memory traces and helps learners reflect, understand, and recall information for specific purposes, such as future recall in an educational setting or as part of a job-related task. Most students employ a wide range of active reading strategies when they are engaged with educational textbooks, particularly when their reading goals include studying for exams or to retain information for a long time. These processes represent activities that are generally necessary for learners to effectively score well on exams and/or retain information that is new to them. Of course, specific strategies may differ from student to student, and individual students may be more or less successful in their active reading pursuits. Regardless, active reading is a critical activity for successful learners (Scheid, 1993; Zile-Tamsen & Marie, 1996). However, there is little to no research that explores whether traditional characterizations of active reading are sufficient for explaining learning process and experience with interactive, multimedia tablet textbooks.

## **1.1 Problem statement**

Tablet textbooks – in spite of their novel annotation features and increasing availability in educational settings – have received little empirical scrutiny regarding how they support and engender active reading. Furthermore, concerns have been raised that tablet textbooks do not sufficiently support students' goals and techniques for consuming educational content as effectively as print texts. Recent studies have found that paper may still be superior to digital platforms for the delivery and consumption of educational textbooks because paper supports a wide range of user requirements, including the fact that multi-document handling (Chen, Guimbretiere, & Sellen, 2012), navigation (Kim,

Kim, & Lee, 2013), and cross-referencing and annotation (Sellen & Harper, 2003) are easier with paper documents. Certainly, tablet textbooks and traditional printed texts provide markedly different learner experiences. For example, the seamless integration of multimedia content alone has the potential to alter reading and learning.

In the tablet textbook environment, students *read* text, *watch* video, and *listen* to audio. However, the textbook invites careful study, review, and annotation. Thus, it is necessary to study how learners effectively *study* in the multimedia tablet textbook environment. Likewise, digital interactivity and non-linear presentation formats may also alter the user experience when it comes to both interaction patterns and usability. Therefore, the strategies learners are accustomed to using for static print textbooks may not be sufficient in the tablet environment. Moreover, although active reading is fundamental to learning, there is little understanding about whether the traditional characterizations of Active Reading sufficiently explain how learners study tablet textbooks. Thus, to effectively assess the quality of tablet-based active reading tools, we must explore a wide range of concepts, from how easy a system is to use and learn, to whether the system successfully supports active reading.

## **1.2 Dissertation goal**

The goal for this dissertation is to address issues in four areas through a series of studies designed to further our understanding of active reading with tablet textbooks:

First, an exploratory study examines strategies learners enact when reading and annotating interactive, multimedia tablet textbooks. This type of textbook design can be distinguished from other digital textbooks because the touch screen affordances of the tablet device and seamless integration of multimedia content lay the foundation for a more complex reading experience. Specifically, this dissertation explores strategies that learners use or wish to use to engage in careful study with textbooks that integrate video-intensive content, animation, and other forms of interactive multimedia in the tablet environment.

Second, this dissertation sheds new light on the nature of active reading with tablet textbooks by uncovering evidence of both usability and cognitive processing problems learners encounter with existing tablet textbook platforms. For example,

findings from this dissertation illustrate that learners often struggle to make sense of and subsequently remember content delivered in multiple media formats, are distracted by the mechanics of interactive content, and grapple with the transient nature of audiovisuals. Ultimately, these findings elucidate directions that are crucial to understanding how to design and develop next-generation active reading tools and tablet textbooks.

Third, this dissertation proposes SMART Note, a suite of novel multimedia annotation tools for tablet textbooks designed to support active reading by minimizing interaction mechanics during active reading, providing robust annotation for multimedia, and improving built-in study tools. The system was iteratively designed and developed through several rounds of usability and user experience evaluation. Furthermore, a comparative experiment found that SMART Note outperformed tablet annotation features currently on the market in terms of supporting learning experience, process, and outcomes.

Fourth, this dissertation revisits the active reading framework with an eye toward further evolving our understanding of what it means to carefully read and study educational material in the digital space. Together the studies conducted for this work serve to extend our understanding of Active Reading in digital environments and tablet textbooks to: (a) recognize the tension between active reading and mechanical interaction with the device; (b) provide designs that facilitate cognitive connections between annotations and media formats; and (c) offer opportunities for personalization and meaningful reorganization of learning material.

### **1.3 Research questions**

The research questions for this dissertation are as follows:

**Q1:** What active reading and learning strategies do learners employ when presented with an interactive, multimedia tablet textbook?

**Q2:** What types of tools must be developed for users to achieve all of their active reading and learning goals in the multimedia textbook environment?

**Q3:** How do novel active reading strategies and features proposed in the SMART Note system compare to the active reading strategies and features provided by leading tablet textbook platforms currently on the market when it comes to usability, efficiency,

active reading experience, and learning outcomes?

**Q4:** How should our current understanding of active reading evolve to include behaviors that emerge when learners engage with educational materials in tablet textbooks?

#### **1.4 Research aims**

Three aims guide this research:

**Aim 1: Identify learners' active reading behaviors when engaged with a tablet textbook.** A preliminary study explored strategies that learners use or wish to use to engage in careful study of tablet textbooks that involve video-intensive content, animation, and other forms of interactive multimedia. Investigating the limitations of existing active reading tools can lead to future designs that leverage the unique affordances of the tablet environment rather than mirroring tools commonly used for active reading in the print environment.

**Aim 2: Introduce and evaluate novel tools that support active reading of audiovisual content in the tablet environment.** Results from the preliminary study were used to identify new tools and novel designs to support active reading in the multimedia tablet textbook environment. Two main areas of focus were identified: 1) improve annotation support for audiovisual content, and 2) strengthen a learner's ability to comprehend and remember information that has been annotated. To address these areas of focus, a novel suite of tools called SMART (Student-centered Multimedia Active Reading Tools) Note were prototyped and iteratively tested in three cycles with 10 users each. An analytical evaluation using a modified Keystroke Level Model (KLM-GOMS) was also conducted to shed light on the efficiency of SMART Note annotation tools compared to a leading tablet textbook platform currently on the market. Additionally, an Active Reading Experience Questionnaire (AREQ) was developed and validated. The questionnaire represents a new instrument for assessing whether specific active reading tools improve the active reading experience. The questionnaire is based on existing active reading frameworks and strategies. The instrument was first validated and then used in a culminating study that compared SMART Note to annotation and study support tools in existing tablet textbook platforms. Specifically, usability, user experience, student

learning outcomes, and levels of efficiency during annotation and study tasks were addressed.

**Aim 3: Extend our understanding of Active Reading to include behaviors that emerge when learners engage with educational materials in the interactive, multimedia tablet environment.** Although the physical and cognitive strategies for active reading are still relevant, the nature of these tasks is significantly different in the interactive, multimedia tablet textbook environment, where interaction mechanics, integrated multimedia, and automatic reorganization of annotations are all deeply connected to the active reading experience.

### **1.5 Significance of dissertation contributions**

The significance of this dissertation to human-computer interaction is threefold:

First, it provides empirical evidence that in spite of the novel affordances and growing popularity of tablet textbooks in educational settings, more research and development is necessary to fully and effectively support active reading in this environment.

Second, this dissertation introduces novel annotation features that support active reading and learning strategies for integrated audiovisual content. These solutions have been developed in light of preliminary research exploring the behaviors and preferences of learners engaged in active reading in the tablet environment. Results from comparative usability and user experience studies should directly benefit digital publishers and interactive textbook designers by offering active reading solutions that specifically address contemporary active reading needs. Additionally, this project should be useful to tablet textbook authors as they consider ways to make educational content more engaging and accessible to student audiences.

Third, this dissertation helps mature our understanding of active reading by proposing new ways to characterize what it means to study tablet textbooks, including recognizing the tension between active reading and mechanical interaction; providing designs that facilitate cognitive connections between annotations and media formats; and offering opportunities for personalization and meaningful reorganization of learning material.

## 1.6 Overview of the dissertation

The remainder of this dissertation is organized as follows:

Chapter 2, *Review of Background*, gives an overview of research previously conducted in two interrelated fields: new literacies and contemporary digital technologies. New Literacies refers to a vast body of literature that explores new forms of literacy and reading activities made possible by advancements in digital technology. This literature explores ways that emerging technologies alter the nature of literacy and related concepts and includes several subsets relevant to active reading and multimedia content, including the Cognitive Theory of Multimedia Learning (Mayer, 2009). New Literacies also explores the influence of digital technologies on novel literacy tasks that require new skills and strategies to effectively use them (Coiro, Knobel, Lankshear, & Leu, 2008). Additionally, related studies of the intersections between contemporary digital technologies and active reading are also relevant. These include research on educational video and annotation, established tablet textbook products currently on the market, and the current state-of-the-art in digital reading technologies. Together, these areas provide an excellent foundation for exploring active reading on tablet textbooks.

Chapter 3, *Theoretical Perspective: Active Reading*, explores the evolution of active reading as a set of strategies for the effective consumption of educational material, from print documents to more recent applications in the digital realm. The application of active reading to digital technologies in the educational arena is critical to forming an understanding of what it means to read and study a tablet textbook.

Chapter 4, *Active Reading Behaviors in Tablet Textbooks*, chronicles a preliminary exploratory study that set out to examine what active reading strategies and/or behaviors emerge when learners engage with multimedia content. Findings identify some limitations of existing active reading tools, which lead to the articulation of key requirements for novel systems to better support tablet-based active reading.

Chapter 5, *SMART Note: Student-centered Multimedia Active Reading Tools*, introduces a suite of novel multimedia annotation tools for tablet textbooks that integrates traditional narrative text with interactive, multimedia content. This chapter also presents results of iterative design, development, and evaluation of SMART Note prototypes tested in two cycles with 10 users each. In each session, a task-based inspection explored

usability and user experience with SMART Note at two levels of fidelity. This iterative development process provided valuable insight about the most effective design approaches for SMART Note active reading support.

Chapter 6, *Comparative Analytical and User Experience Evaluation*, first reports findings from a task-based analytical evaluation to measure annotation efficiency. This evaluation used a modified KLM-GOMS method to compare annotation functionality of SMART Note to Inkling Habitat, the leading tablet textbook platform currently on the market. A final usability study was also conducted to compare SMART Note to Inkling Habitat annotation features. Findings from both studies suggest that SMART Note features are both more efficient and easier to use than features available in existing tablet textbooks.

Chapter 7, *Developing and Validating a New Instrument for Evaluating Active Reading Experience*, presents the Active Reading Experience Questionnaire (AREQ), which represents a notable contribution to user experience research, as it provides a novel instrument for assessing how well a specific tool or interactive system supports active reading. A three-part validation study of the 29-question survey included initial development based on a review of extant literature in active reading, a five-member expert analysis to establish content validity, and a thought experiment with 50 undergraduate students to establish criterion validity and item-to-total reliability.

Chapter 8, *Comparative Assessment of Active Reading in a Natural Setting* reports on a final study that used the AREQ, other user experience measures, and knowledge quizzes to again compare SMART Note to Inkling Habitat annotation features on learning experience, process, and outcomes. Results showed that SMART Note performed significantly better on most measures.

Chapter 9, *A Novel Perspective of Active Reading on Tablet Textbooks*, proposes an extension to our understanding of Active Reading that more accurately characterizes the learner experience with interactive, multimedia tablet textbooks. Suggestions for future research and development are also included.

Finally, Chapter 10, *General Discussion and Conclusion*, summarizes key contributions of this dissertation and presents plans for future research.



## **2 Review of Background**

There are a number of interrelated fields relevant to active reading in the tablet textbook environment. In addition to literature on active reading alone (which is covered in Chapter 3 as the theoretical underpinning of this dissertation) previous literature concerning new literacies and contemporary digital technologies is also relevant. Thus, in order to better understand the ways in which emerging technologies alter the nature of active reading, this chapter reviews previous literature in four areas: 1) intersections between literacy and technology, 2) video annotation, 3) existing tablet textbook products currently on the market, and 4) current state-of-the-art in digital reading technologies.

### **2.1 Intersections between learning and technology**

A vast body of literature that explores new forms of literacy and reading activities made possible by advancements in digital technology has been steadily growing for the past 20 years. First mentioned in an academic article in 1993 (Buckingham, 1993), *new literacies* has since emerged as a broad way of categorizing research that explores the influence of digital technologies on novel literacy tasks that require new skills and strategies to effectively use them. As such, the definition of new literacies remains open, as different scholars have conceptualized and characterized it in different ways. New literacies is an expansive concept that includes several subsets, such as *21<sup>st</sup> Century literacies*, *Internet literacies*, *digital literacies*, *new media literacies*, *multimedia literacy*, *multiliteracies*, *information literacy*, *computer literacies*, and so forth. All have been used to refer to phenomena falling broadly under a new literacies umbrella (Coiro, Knobel, Lankshear, & Leu, 2008).

Several of these categories are relevant to active reading in the tablet textbook environment. However, one in particular – multimedia literacy – drives to the heart of the knowledge, skills, and behaviors present in the use multimedia tablet textbooks. Broadly speaking, multimedia literacy “refers to being able to generate multimedia communications that others comprehend and to comprehend communications that others generate” (Mayer, 2008, p. 359). Thus, effectively supporting active reading in the multimedia tablet textbook environment must begin with a clear understanding of how multimedia messages are best presented and then developing annotation and study tools

that are uniquely suited for the tablet textbook environment through designs that adhere to core multimedia literacy principles.

### ***2.1.1 The Cognitive Theory of Multimedia Learning***

For the past 15 years, Richard Mayer and colleagues at the University of California, Santa Barbara have been studying how to create multimedia messages that people can understand. Through these pursuits, he has consistently argued that the conception of literacy should be expanded to include words and images, as well as moving pictures and other forms of multimedia. This focus on multimedia literacy “is based on the premise that people understand more deeply when scientific explanations are presented with words and pictures than with words alone” (Mayer, 2008, p. 360).

Mayer refers to this idea as the multimedia principle, and in nine experiments, he found that students perform better on problem-solving transfer tests when they study presentations that include pictures with explanatory text or animation with narration than when they study words alone (Mayer, 2002a). Experiments involved presenting learners with different representations of the same information, including a text-only condition, a pictures + words condition, and an animation + narrative audio condition, to explore which format resulted in better learning outcomes. Additional experiments focused on the effects of visual and verbal redundancies on recall, the placement of words in relation to images, and whether the length of audiovisuals affected memory, to name a few (Mayer, 2009). However, not all multimedia messages are equally instructive. Thus, multimedia literacy research has focused on helping students maximize the effectiveness of their multimedia communications and providing educators with rules for generating effective multimedia messages.

Mayer asserts that the challenge for multimedia authors is to create multimedia messages that minimize extraneous cognitive processing, emphasize essential material/information, and help learners make sense of relevant words and pictures by making connections between them and with prior knowledge (Mayer, 2008). In this sense, even the simplest forms of multimedia learning represent “a demanding process that requires selecting relevant words and images, organizing them into coherent verbal and pictorial presentations, and integrating the verbal and pictorial presentations with

each other and with prior knowledge” (Mayer, 2009, p. 75). Thus, it stands to reason that the interactive tablet textbook represents a heightened level of complexity by integrating content delivered in several media formats and designed as a browse-able book. Although Mayer’s research has not focused on multimedia in tablet textbooks specifically, his work can be quite instructive for the development of tablet textbooks that integrate multimedia. Specifically, Mayer (2009) offers several principles for effective learning with multimedia that are relevant to tablet textbooks.

#### *2.1.1.1 The segmenting principle*

According to the *segmenting principle*, people learn better when a multimedia lesson is presented in learner-paced segments rather than as a continuous unit. Thus, breaking narrative explanations into bite-sized parts is less taxing on working memory and can help learners more effectively process complex information. Mayer reported that students repeatedly performed better on tests when they received segmented multimedia lessons rather than continuous ones (Mayer, 2005). It stands to reason that the segmenting principle should be considered in the design of tablet textbooks that integrate narrative videos. In fact, this principle could even inspire new annotation and/or study tools that allow learners to mark and efficiently review shorter segments of longer videos in personally meaningful ways.

#### *2.1.1.2 The signaling principle*

According to the *signaling principle*, people learn better when the words include cues about the organization of the presentation. Mayer (2008) asserts that because it may not always be possible to eliminate all potentially extraneous material from a multimedia explanation, “guiding the learner’s cognitive processing by highlighting essential material” (p. 365) could be an effective way to stimulate memory. This principle has strong ties to similar active reading strategies that are intended to help learners focus on the most important information in a text. Thus, tablet textbook multimedia presentations could include visual and/or functional cues that alert learners to the most important information, such as key term definitions or topics. Likewise, educational videos and

animations should include active reading support tools that allow learners to easily and effectively mark and/or review those salient concepts.

#### *2.1.1.3 The spatial and temporal contiguity principles*

The *spatial contiguity principle* asserts that people learn better when corresponding words and pictures are presented near rather than far from each other on the page or screen. Similarly, the *temporal contiguity principle* notes that people learn better when corresponding words and pictures are presented simultaneously rather than successively. These principles are relevant to active reading on tablet textbooks in that they illuminate the value of presenting words and images together as a means for cognitively solidifying complex concepts and mitigating the often-transient nature of audiovisuals. In other words, supporting active reading in the tablet textbook environment involves effectively engaging the auditory channel and the visual channel to mitigate the threat of increased cognitive load that is associated with consuming complex audiovisuals that include transient narrative audio and moving pictures.

#### *2.1.1.4 Cognitive load and multimedia learning*

Multimedia learning theory also draws on the Cognitive Load Theory (Sweller & Chandler, 1991), which asserts that working memory is limited with respect to the amount of information it can hold and the number of related operations it can perform. As a result, when the cognitive demands presented by two related tasks overlap, a learner's ability to effectively process and understand information provided by those tasks is diminished. When it comes to educational multimedia, one example of related overlapping tasks is watching video while reading related captions or transcripts. Because both of those tasks require a learner's visual attention, cognitive load is increased for effectively processing all of the information. In the tablet textbook environment, cognitive load might also be increased if mechanical interaction with the device—such as rewinding video or engaging in multi-tap interaction patterns to access or annotate information—distracts learners from actually focusing on and effectively studying the content. Such mechanical interaction represents “a form of overhead that does not contribute to an understanding of the materials” (Brunken, Plass, & Leutner, 2003),

therefore it should be minimized as much as possible. However, Dual Coding Theory posits that visual and verbal information are processed along two distinct channels in the human mind, creating separate representations for information that is passed through each channel (J. M. Clark & Paivio, 1991). With only a few exceptions, adding relevant pictures (static or animated) to words has a positive effect on learning (Levie & Lentz, 1982). Thus, well-designed multimedia messages can foster deeper understanding because they are learner centered as opposed to technology centered (Mayer, 2009).

Clearly, authors of multimedia content should not take the task lightly. The effectiveness of any single video presentation or animation relies heavily on whether the author can strike the right balance between accurate visual representations, clear audio narrative, and freedom from mechanical interaction that threatens to undermine a learner's focus. This is no simple task, as the integration of video annotation tools in tablet textbooks adds yet another layer of complexity to video consumption and interaction. Furthermore, the Cognitive Theory of Multimedia Learning is focused quite narrowly on multimedia instructional messages presented individually in just two presentation formats, verbal and pictorial (Mayer, 2009). Although these formats represent the bulk of possible multimedia combinations (i.e., written words, spoken words, static images, and animations), Mayer also asserts that more work is necessary to determine how multimedia authors and publishers can implement established principles of multimedia learning in other new environments like tablet textbooks (R. C. Clark & Mayer, 2011). Therefore, this dissertation draws on the Cognitive Theory of Multimedia Learning for inspiration in the design of novel active reading support for audiovisuals by honoring the segmenting, signaling, and spatial and temporal contiguity principles, while at the same time working to minimize extraneous cognitive load. Since the primary focus of multimedia active reading support is on educational video and animation, a brief look at prior research on video annotation is also relevant.

## **2.2 Video annotation**

By 2009, video was the third most popular media format for the delivery of educational content (Purcell, 2010). Prior research asserts that learners prefer instructional video to text and are more likely to gain a deeper understanding of content

from video than from words alone (Baggett, 1984; Mayer, 2002b, 2003; Mayer & Moreno, 2002). There is additional evidence that video content is more memorable than text-based content (Jonassen, Howland, Moore, & Marra, 2003). Bates (1985) and Davis (1988) suggested that video is most valuable for facilitating narrative visualization, simulation, and abstracting information from real life scenarios. As a result, contemporary tablet textbook publishers often tout integrated and interactive multimedia as part of the unique experience digital textbooks offer that traditional print texts cannot.

On the other hand, processing educational video may increase cognitive load because it is difficult for students to simultaneously synthesize visual and auditory streams of information and extract the semantics of the message (Homer, Plass, & Blake, 2008). Furthermore, research suggests that in educational contexts, a series of static images may be just as good or even better than video because the dynamic and transient nature of videos makes it difficult for students to quickly process information (Catrambone & Seay, 2002; Hegarty, Kriz, & Cate, 2003; Hegarty, Narayanan, & Freitas, 2002; Mayer, 2005; Tversky, Morrison, & Betrancourt, 2002). Therefore, a key concern in using video as an instructional device is the need to create conditions for learners' cognitive systems that help address the processing demands needed to organize and integrate knowledge from dynamic media like video (Ibrahim, 2012). These concepts are extremely relevant to active reading on tablet textbooks, as the integration of video into a textbook design may create a more complex environment for reading and studying. Thus, tablet textbooks that integrate multimedia must be designed to minimize cognitive load and support active reading by providing easy-to-use annotation and organizational tools.

During the past 20 years, a number of researchers have proposed a few best practices for the development of educational video. For example, most experts agree that video is more effective in short segments that are easy to digest (Shephard, 2003). Likewise, to maximize learners' concentration, video should be concise and clearly identify what should be learned from it (Shephard, 2001). However, some researchers have discounted video as an active learning medium because it does not easily and on its own support active learning (Laurillard, 2013). Therefore, when it comes to the integration of video presentations in tablet textbooks, an opportunity exists to provide active reading support tools that cater the unique cognitive demands introduced by

educational multimedia. To date, only a few researchers have explored new strategies for the development of effective video annotation platforms.

In a three-year diary study, Vondrick, Patterson, and Ramanan (2013) explored how well their novel video annotation interface supported crowdsourcing to annotate videos. Through several user studies that evaluated different aspects of the system, the researchers demonstrated that minimizing cognitive load associated with interactive systems is critical when designing annotation platforms. Furthermore, they argue that video annotation requires specialized skill and that most people are poor annotators, therefore requiring annotation systems to include robust and intuitive functionality. Similarly, others have built and then studied novel systems for supporting video annotation alone. For example, Markitup (Chircop, Radhakrishnan, Selener, & Chiu, 2013) offers shared, crowd-sourced annotations to help overcome distraction that occurs with hypermedia annotations. Likewise, Nguyen, Kim, and Miller (2013) developed a process for generating video annotations on tutorials involving metadata and crowdsourcing. Advene (Aubert & Prié, 2005) promotes hypervideo creation and annotating videos for Internet distribution. MADCOW (Bottoni et al., 2004) supports annotation of individual video documents. However, none of these systems have focused specifically on annotation systems for tablet textbooks that require learners to study information delivered in multiple formats designed as a browse-able book. As a result, there exists an opportunity to explore what unique requirements emerge for active learning with audiovisuals in the tablet environment. Based on those requirements, we can then build and test novel video annotation systems that leverage the intrinsic benefits of video and minimize cognitive load associated with interactivity and audiovisual learning.

### **2.3 Established tablet textbook products currently on the market**

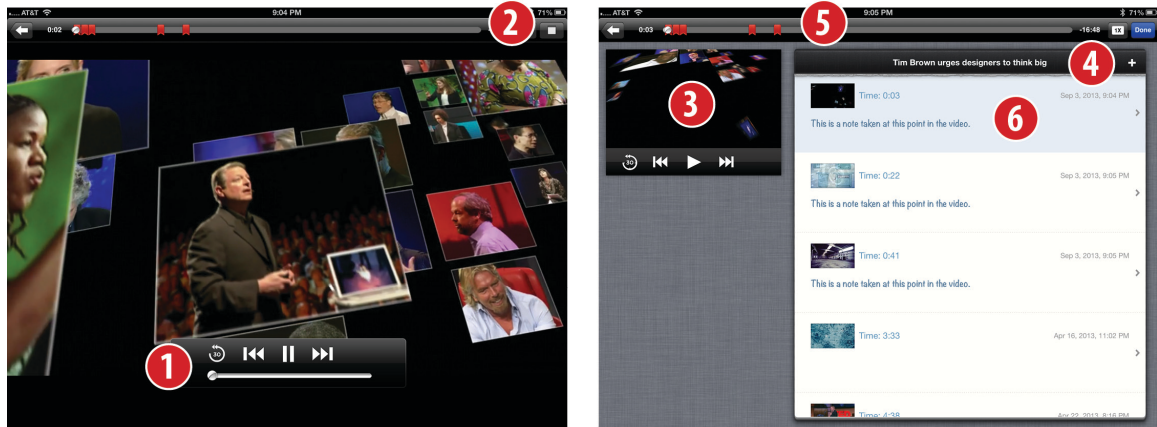
The tablet has evolved as a technology in its own right, blending rich multimedia potential and features of laptops and earlier eReaders with always-connected Internet. Furthermore, since the introduction of the iPad in June 2010, “the tablet” has become distinct from other types of mobile devices (Johnson et al., 2013). By October 2014, Apple had sold more than 200 million iPads, and tablet device sales are projected to

increase exponentially through 2018 (Costello, 2014). Likewise, researchers with the online educational firm Xplana assert that the shift toward tablets will be a game-changer when it comes to how students access and consume educational content. Tablets have gained traction in education, as a number of traditional publishers, namely Pearson and McGraw Hill, along with the award-winning cloud-publishing platform Inkling Habitat, have taken the lead in the interactive textbook market.

In 2011, Pearson Education partnered with Inkling Habitat to test-drive new interactive textbooks at several universities (Coombs, 2011) and re-imagine the traditional textbook to provide students with a more robust multimedia experience. In 2014, McGraw-Hill Education selected Inkling Habitat, for building McGraw-Hill Education's next-generation learning products and tablet textbooks (Hebbard, 2014). Inkling books boast a number of useful features including the ability to highlight text, take notes, and explore clickable keywords; bookmark pages and sections of a text and mark helpful notes others have posted in social learning network; and browse collections of highlighted text, notes, reading history, and glossary terms. Inkling books also allow learners to follow anyone using the same book, see their notes and highlights, and create running discussions. Other companies like Course Smart (<http://www.coursesmart.com/>), VitalSource Bookshelf (<http://support.vitalsource.com/>), and Kno (<http://www.kno.com/>) tout similar platforms, all of which provide tools for annotating and studying text, but none of which provide equally effective solutions for studying multimedia content.

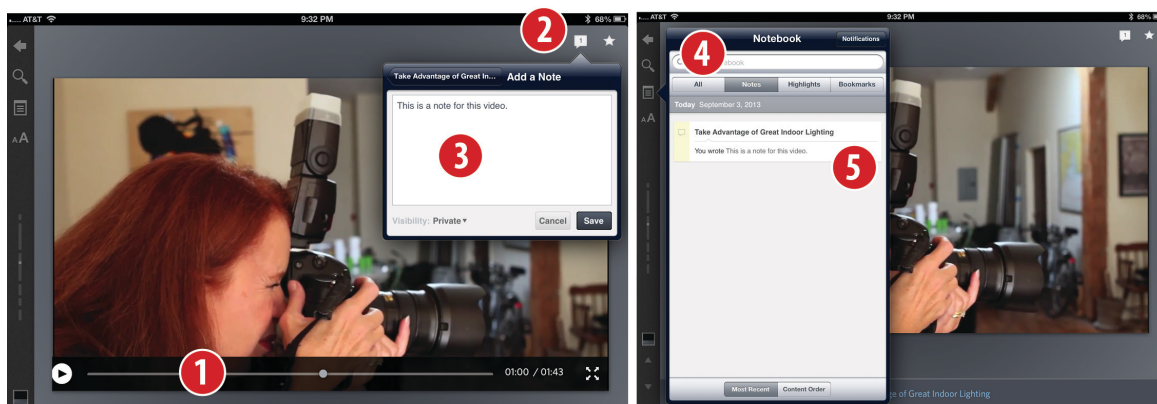
The most sophisticated video annotation tool for tablets is iTunes U, an open-course platform that allows users to download and subscribe to educational content shared by organizations like TED, lecturers and professors, and other students. It is worth noting that iTunes U is not a tablet textbook platform. Rather, it is a course content delivery system. However, iTunes U does supply some elegant, easy-to-use annotation tools, including the ability to bookmark and add notes to points in the video timeline and then use those annotations as a means for navigating back to portions of the video that a learner wants to review. Likewise, users can filter and combine video annotations with notes taken on related reading materials. Figure 2.1 illustrates the iTunes U audiovisual annotation functionality. Most tablet textbooks, however, lag behind iTunes U when it





**Figure 2.1. iTunes U audiovisual annotation functionality: 1) Use controls to pause, rewind, fast-forward, or jump back in 30-second increments; 2) take notes by tapping the notepad icon; 3) Video shrinks and continues to play; 4) add a note by tapping the + button; 5) a bookmark appears on the timeline corresponding to the annotation; 6) a frame grab from the point in the video you tagged appears along with your notes. Notes can be used as hyperlinks to navigate back to points in video.**

comes to audiovisual annotation features and browse-able notes. Inkling, the most widely adopted platform to date, offers a much less robust set of audiovisual annotation tools (illustrated in Figure 2.2). Likewise, the most popular development and publishing solution available to authors who wish to create tablet textbooks with built-in multimedia is Apple's iBook Author (<http://www.apple.com/ibooks-author/>), which provides only minimal annotation features, including widgets for integrating multimedia content and built-in highlighting and annotation tools for text.



**Figure 2.2. Inkling audio visual annotation functionality: 1) In full-screen mode, use controls to pause, rewind, or fast-forward; 2) to take notes, tap the notepad icon; 3) in the dropdown, add and save notes while video continues to play; 4) tap the notebook icon on the left to view, search, and filter annotation by “notes,” “highlights,” or “bookmarks”; 5) tap individual notes to navigate back to the portion of the video or text from which they originated.**

Study tools currently available on tablet-based textbooks are generally not device-specific, although some book-making software is exclusive to certain devices. For example tablet textbooks made with Apple's iBooks Author can only be accessed on iOS devices. However, individual active reading features, such as highlighting, annotating, and reorganizing content into personally meaningful ways, are generally based on the type of software/programming used to make a particular text, not the device on which it will be viewed. In other words, all tablets (e.g., iPad, Kindle Fire, Samsung Galaxy, Nook) are capable of supporting features like highlighting, because the interaction is marked by a simple swipe of the finger.

Nonetheless, competition for the tablet textbook market is relatively oligopolistic, with Inkling Habitat quickly becoming a leader of the mobile-era publishing revolution. In 2014, *Fast Company* named Inkling one of the World's 50 Most Innovative Companies, and the world's leading publishers are rebuilding their best titles on the Inkling platform into engaging and interactive reading experiences. However, research that explores new tablet designs and optimal interaction patterns for educational reading continues to emerge.

#### **2.4 Current state-of-the art in digital reading technologies**

New systems to simulate paper experiences and support novel ways of annotating, marking-up text, and collecting content for future review in eReader environments have surfaced. Chen, Guimbretiere, and Sellen (2012) propose "multi-slate," a new type of electronic reading device that is composed of several light-weight, interconnected "slates" that simulate some of the strengths of traditional paper documents. The authors argue that "multi-slate" is necessary because existing electronic reading devices, such as tablets and eReaders, fail to provide learners with the wide range of flexibility that is required for active reading. Chen et al., also report that early usability studies found that users were generally positive about the multi-slate experience, noting that sequential reading and orientation in the multi-slate environment were as effective as they were when documents were presented in paper form. Matulic and Norrie (2012) present the use of pen and touch-operated tabletops for performing active reading tasks, such as annotating, smooth navigation, and rapid searching. They found that the pen-and-touch

system was better for active reading tasks than paper alone or PDF editing tools found in Acrobat Reader. Similarly, GatherReader (Hinckley, Bi, Pahud, & Buxton, 2012) features both pen and multi-touch input, allowing users to interleave content consumption behaviors with information gathering and organization strategies. Hinckley, et al., assert that the GatherReader design provides flexible tools for making notes and gathering annotations, while keeping users in the flow of the primary task of reading the text itself. However, pen and touch users have noted a number of hardware and software limitations that impede user experience, such as limited screen space and difficulty with pen and touch operations (Matulic & Norrie, 2012). Users encountered similar difficulties with PapierCraft, a system that simulates paper with tablet PCs, but also suffered from loss of invaluable paper affordances (Liao, Guimbretière, & Hinckley, 2005). For example, users favored paper over digital reading devices because it is lighter and easier to hold. Likewise, many users indicated that special arrangement and page comparison were easier when working with paper. These studies suggest that systems that combine the affordances of paper and computers may be promising alternatives for overcoming some of the challenges students encounter with educational content in the eReader/tablet environment.

For example, Tashman and Edwards introduced LiquidText (2011) as a computer-based active reading system that offers flexible document representation and a range of interaction techniques designed to facilitate active reading. Their user experience research suggests that learners favor direct manipulation control of the visual arrangement of content and annotations and flexibility in navigating through content. Likewise, researchers have proposed and studied new design paradigms for interactive eBooks (Colombo & Landoni, 2011; McFall, 2005). Colombo & Landoni (2011) found youngsters were enthusiastic about the novelty of eBooks, but also reported “the book is no longer a tangible object with its various dimensions (weight, thickness, font size, even the ‘scent’)” (p. 63). In a study that engaged students with an “electronic textbook” on a Tablet PC, McFall (2005) assessed student learning and perceptions. McFall’s group found that although students were pleased with the eTextbook experience, no significant differences in student learning or textbook usage were observed between students using the electronic and paper versions of the textbook. Thayer, et al. (2011) found that

“...issues related to reading process remain underexplored in studies of eReaders in academia, partly because students’ goals and techniques for reading academic texts were not considered” (p. 2919). Thus, any design for novel active reading support must consider the nature of reading comprehension and common goals and practices of educational reading.

In the Chapter 3, Active Reading is presented as the primary theoretical lens through which this dissertation has been developed. Foundational to learning, active reading is the full realization of the constructive nature of reading comprehension. During active reading learners build highly personalized physical and cognitive frameworks of the materials they read by applying specific strategies, such as annotating, summarizing, and developing study guides or other artifacts. These artifacts often leave strong memory traces, allowing learners to more effectively comprehend, memorize, synthesize, and recall information.

### 3 Theoretical Perspective: Active Reading

Active reading is fundamental to meaningful learning. During active reading, learners build and analyze the materials they read by applying specific strategies, such as annotating, summarizing, and developing study guides or other artifacts in an effort to comprehend, memorize, and synthesize information. Thus, active reading serves a fundamental meta-cognitive function that allows content to leave strong memory traces and helps learners understand a text for a specific purpose, such as future recall in an educational setting or as part of a work-related task. Active reading is one of the fundamental methods often included under the broader umbrella of *active learning*, which also comprises other instructional models, such as learning by teaching, class discussion, and collaborative learning groups, to name a few (Bonwell & Eison, 1991).

During the past four decades, a vast body of literature has emerged that seeks to characterize active reading specifically based on the cognitive and physical processes learners enact to better understand educational content. Active reading originated as a guiding framework with, “How to Read a Book: The Classic Guide to Intelligent Reading” (Adler & Van Doren, 1972). The authors defined active reading as a set of activities that should guide the educational reading process. Since then, many studies have indicated that students employ a wide range of active reading strategies when they are engaged with educational textbooks, particularly when their reading goals include studying for exams or to retain information for a long time (Anderson, 2002, 2009; Balajthy, 1984; Irwin & Baker, 1989; Ogle, 1986; Simpson & Nist, 2002; Tashman & Edwards, 2011a; Vaughan, 1982). Of course, specific strategies may differ from student to student, and individual students may be more or less successful in their active reading pursuits. However, many scholars agree that good active reading skills are critical for students to become successful learners (Scheid, 1993; Zile-Tamsen & Marie, 1996).

Early definitions of active reading focused on reading text in print. However, the strategies and behaviors that define active reading as a conceptual approach to learning are applicable to the consumption of other types of media as well. For example, the emergence of digital textbooks – complete with integrated multimedia content – has prompted research that explores how emerging technologies alter the nature of literacy and related concepts. Likewise, the rising popularity of tablet use among students (e.g.,

iPads and similar Android devices) is moving textbooks to the mobile arena. Thus, active reading, watching, and listening, as well as engaging with interactive content, all become seamlessly intertwined with the active reading process, particularly as learners attempt to annotate and study content delivered in multiple media formats.

As a result, it is now possible to extend the active reading framework to research that aims to discover what, if any, novel traits of active reading emerge when learners engage with a particular reading assignment. For example, how can learners' annotation goals be adequately supported in digital environments and/or on mobile devices? Likewise, how can active reading support be effectively applied to multimedia content, particularly when it is integrated with narrative text, images, and graphics in a textbook design? The active reading framework can also be used to identify novel directions for supporting learners in their efforts to carefully study material they have already read and annotated. For example, how can learners' active reading goals be supported when annotations are automatically concatenated in the digital space? To answer these questions, key requirements for novel systems to better support educational active reading of tablet textbooks must be grounded in relevant theories of active reading and learning.

The sections that follow chronicle some of the most influential articulations of active reading, from early frameworks that explore cognitive approaches to reading comprehension, to more recent characterizations that include references to digital technologies.

### **3.1 Active reading as an evolving framework**

"How to Read a Book: The Art of Getting a Liberal Education" was first authored in 1940 by Mortimer Adler, an American philosopher, educator, and popular author. In it, Adler laid the foundation for a guide to intelligent reading that was particularly focused on the college-bound student. However it wasn't until 1972, when Adler co-authored a heavily revised edition ("How to Read a Book: The Classic Guide to Intelligent Reading") with academic Charles Van Doren, that the concept of Active Reading emerged as a framework for critical reading.

This early framework includes *structural*, *interpretative*, and *critical reading*, and any or all of the following purposes for reading a text: to understand a document's structure or purpose; to understand an author's meaning, arguments, and terminology; or to critically assess the merit and accuracy of a text. Regarding their motivation for identifying this framework, the authors assert,

“... given the same thing to read, one person reads it better than another, first, by reading more actively, and second, by performing each of the acts involved more skillfully. These two things are related. Reading is a complex activity, just as writing is. It consists of a large number of separate acts, all of which must be performed in a good reading. The person who can perform more of them is better able to read” (p. 6).

The authors lay out a method for reading educational texts with the specific goal of gaining understanding. They note that structural, interpretative, and critical reading are three distinct approaches to reading that are all necessary to achieve the highest level of understanding, and experienced readers can interleave them in the course of reading the book just once.

Structural reading is concerned with understanding the structure and purpose of the book. It begins with forming a basic understanding of the topic of a book and identifying the problems the author is trying to solve. Interpretive reading involves constructing the author's arguments, while making sure to understand any special phrases and terms that the author uses. Finally, critical reading requires a reader to criticize the book. The authors assert that once a reader understands the text, he should now be able (and obligated) to judge the book's merit and accuracy. Adler and Van Doren's characterization of active reading, therefore, is primarily focused on a learner's obligation to understand authorial intent as a way to engage in effective meaning making. Contemporary scholars have sometimes called this process the *Structure-Proposition-Evaluation (SPE)* method, (Kuprashvili, 2013) although this term is not used in Adler and Van Doren's book.

Furthermore, Adler and Van Doren begin to lay the groundwork for understanding the physical processes that learners use during active reading. For example, the authors discuss, in detail, the importance of three types of annotation, *structural*, *conceptual*, and *dialectical* note making (p. 50). They assert that structural annotation involves determining and noting an author's key ideas about a subject.

Conceptual annotation is based on analytical reading and involves a reader's ability to answer questions about the truth or significance of a piece. Dialectical annotations pinpoint the shape of discussions among different sources of information. Thus, dialectical annotation begins to suggest a cross-referencing process, as learners seek to make connections among arguments within a single text and between different texts. In addition, the authors discuss the art of outlining as a means for organizing one's thoughts about meaning, importance, and significance related to the core structure of a text. They refer to the outline as a "skeleton" that represents the structure of the text, and the "writing out" of the outline as the exercise that gives life and "flesh" to the skeleton (p. 90). They refer to this phenomena is the reciprocal nature of reading and writing and assert that strong outlines have unity, clarity, and coherence of thought.

A few years later, A.K. Pugh elaborated on the work of Adler and Van Doren with his book, "Silent Reading: An Introduction to Its Study and Teaching" (1978). The research that led to this piece focused heavily on readers' eye movement in normal educational reading scenarios to assess exactly how skilled silent readers extract important information from texts (Pugh, 1979). An early example of "eye track research," Pugh used an apparatus he designed in three different experiments to chart eye movement of readers in an effort to discover strategies they use to locate information in a text. Pugh found that there are several key characteristics of responsive reading that are both cognitive and physical, and that both categories are intricately intertwined with a learner's purpose for reading. Thus, Pugh's characterization of active reading is primarily driven by a learner's information consumption goals as a way to engage in effective meaning making. He articulated these characteristics as Responsive Reading, which goes a step further than earlier definitions of active reading. He notes that the linear progression through a text, reading to search for specific information, reading to acquire information without a set goal, and reading to get an overview of the general structure of a text are all very different activities. Furthermore, these cognitive functions can be supported through specific physical strategies, and Pugh explicitly focuses on note taking, annotating, and cross-referencing as three fundamental tasks.

These seminal works on active reading influenced the conceptualization of a number of teaching and learning strategies. For example, the Survey-Question-Read-



Recite-Review (SQ3R) method (Robinson, 1970), often taught in public schools, has led to a number of key recommendations for active readers, including asking questions of oneself before, during, and after reading; identifying and defining unfamiliar terms; identifying and marking key points in a text; making flash cards, outlines, flow charts, diagrams, concept maps, and other artifacts; making notes of analysis, comparison, and synthesis of ideas; and teaching what is learned to someone else (Artis, 2008; Carlston, 2011; Zhang, Cheng, Huang, He, & Koyama, 2002). Likewise, K-W-L (Ogle, 1986) is a similar method that encourages learners to list what is “Known” about a topic based on prior knowledge; determine what additional information they “Want” to learn; and then identify what they “Learn” after instructional events, such as reading educational material. Models like these illustrate the active nature of reading instruction that is inspired by the work of Adler, Van Doren, and Pugh, as it is meant to help learners synthesize and make sense of what they read.

Adler et al. added Work-Related Reading to the discussion of active reading in 1998, which also addressed the then-emerging digital environment. They noted that in the digital age, learners often read and annotate several documents or digital displays concurrently. They also pointed out that reading more often happens along with writing – annotation, outlining, etc. – then without. In a diary study that required 15 subjects to log their daily document activities during the course of their working day, the researchers found that for much of the work day, subjects were involved in rapid and goal directed types of reading comprised of browsing, skimming, and searching to answer questions. “This points to the need to consider digital reading devices that support fast and flexible search, manipulation, and navigation” (p. 243). It is notable that even more than a decade before the first iPads hit the market, these researchers were already beginning to consider how active reading is best supported in digital environments. And although all of the core physical activities acknowledged by prior work are still relevant, Adler et al. recognized that in the digital space, these activities might take different shapes. “The fundamental problem,” they assert, “is that the task of ‘reading’ is far too general and ubiquitous: reading takes on a range of forms, is done for a variety of purposes, and is embedded and related to many other document-based activities” (p. 241). As a result, studies of active reading should consider the format of the reading material (i.e., paper documents, digital

documents, documents viewed on reading devices vs. computer screens, etc.) as part and parcel of the active reading experience.

Table 3.1 summarizes the three foundational models of active reading, beginning with Adler and Van Doren’s Active Reading, continuing with Pugh’s Responsive Reading, and ending with Adler et al.’s Work-Related Reading. Of course, many researchers have since made additional contributions to our understanding of best practices for teaching and learning through active reading. The models previously noted (SQ3R and K-W-L) represent just a couple of many recommendations for teachers and learners. However, the majority of similar articulations of “best practices” for active reading are based on the characterizations outlined in Table 3.1.

<b>Model</b>	<b>Key Characteristics</b>	<b>Physical Strategies</b>
<b>Active Reading</b> (Adler & Van Doren, 1972)	<b>Structural reading:</b> Understand the structure and purpose of a text <b>Interpretative reading:</b> Understand author’s arguments, special phrases, terms <b>Critical reading:</b> Judge the merit and accuracy of a text	<ul style="list-style-type: none"> <li>• Note making</li> <li>• Outlining (reorganizing)</li> <li>• Cross-referencing</li> </ul>
<b>Responsive Reading</b> (Pugh, 1978)	<b>Linearly progressing</b> through the text without interruption (i.e., receptive reading) <b>Reading to search</b> for a specific piece of information <b>Reading to acquire</b> information without a set goal <b>Reading to get an overview</b> about the general structure of the material	<ul style="list-style-type: none"> <li>• Annotation</li> <li>• Cross-referencing</li> <li>• Reorganizing</li> </ul>
<b>Work-Related Reading</b> (Adler, Gujar, Harrison, O'Hara, & Sellen, 1998)	Reading that happens more frequently with writing than without and is performed across several documents or displays concurrently	<ul style="list-style-type: none"> <li>• Annotation</li> <li>• Browsing</li> <li>• Cross-referencing</li> </ul>

**Table 3.1. Foundational characterizations of active reading**

### **3.2 Understanding the physical nature of active reading**

Active reading scholars commonly assert that to read effectively, it is necessary for learners to interact with the reading material. The key characterizations of Active Reading, Responsive Reading, and Work-Related Reading outlined in Table 3.1 center on

the cognitive processes and purposes for reading and suggest a metacognitive awareness that can be enhanced through systematic, direct instruction (Mokhtari & Reichard, 2002). However, Active Reading, Responsive Reading, and Work-Related Reading also refer to similar physical strategies learners use to access, extract, and acquire information and knowledge from their reading materials. Collectively, we can refer to these as the “four physical strategies” inherent in most educational active reading scenarios, all of which surface time and again in literature that aims to define both the cognitive and tangible aspects of active reading.

For example, learners often highlight or underline passages of text to easily refer back to important points, make notes in margins to synthesize ideas, and circle key terms or otherwise mark their reading materials to hone in on the core message of a text. This process of *annotation* is part of the critical reading process, which is essential to academic success and intellectual growth. According to authors of Harvard Library’s guide to effective study habits, *Interrogating Texts* (2007), “Annotating puts you actively and immediately in a ‘dialogue’ with an author and the issues and ideas you encounter in a written text. It’s also a way to have an ongoing conversation with yourself as you move through the text and to record what that encounter was like for you” (p. 1). Thus, annotation is more than a means to an end. Rather, it is a fundamental task used to interpret, critique, and subsequently search for key information.

Successful learners often elaborate annotation efforts by outlining or organizing information to enable them to see the skeleton of an argument, the thesis, main points, evidence, and so on associated with a text. Not only does an outline provide a framework for studying that condenses a text down to its most salient parts, but the act of *making* the outline requires learners to restate main ideas, as they take the information apart, analyze it, and then try to put it back together again in language that is meaningful to them (*Interrogating Texts*, p. 2). Reorganization activities, such as making flash cards, affinity diagrams, or other physical artifacts, can be similarly effective, and together, these activities represent the process of *reorganization* as part of structural reading. Reorganization provides an avenue for Pugh’s emphasis on searching for specific information and accessing an overview of the general structure of the material in personally meaningful ways.

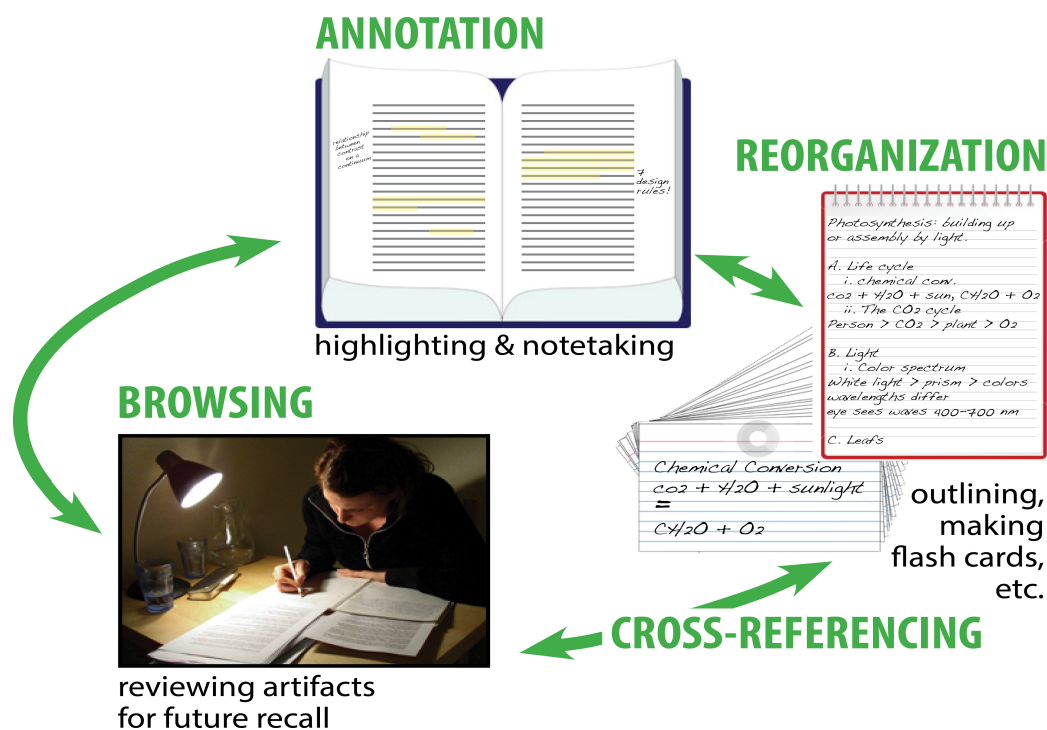
Understanding the structure and purpose of a text doesn't always have to involve deep, focused reading, as learners often engage in previewing or skimming their reading materials in an effort to quickly orient themselves to the content. Adler and Van Doren first referred to "skimming" as part of structural reading, and noted that adept active readers often do so before diving deeper into complex materials. Adler et al. later used the term *browsing* to refer instances in which individuals said they did not read in detail, but rather to get a general sense of the content of a piece of writing. However, it is worth noting that browsing may also occur when learners review annotations, outlines, flash cards, and other artifacts generated during active reading as a means for studying information, as the "active reader can experience an enriched reading of the document that builds upon the marks, allowing him to locate or search for interesting information" (Aubert, Champin, Prié & Richard, 2008, p. 428).

Finally, in the active reading arena, learners often engage in a process of *cross-referencing* both among documents and within a single document. This cross-referencing allows active readers to effectively compare and contrast, make connections among related content, contextualize their reading, and find patterns in the reading that would indicate what an author considers crucial information. Once annotations, outlines, and similar artifacts are generated, cross-referencing also occurs between annotations and original text, as learners seek to make sense of and understand the materials.

Figure 3.1 illustrates how these strategies operate together. It is important to recognize the reciprocal and cyclical nature of these activities, as learners often engage them simultaneously and/or multiple times in a single reading session.

### **3.3 Active reading as a foundation for digital multimedia environments**

In the interactive systems research community, active reading has been repeatedly characterized as notoriously difficult to adequately support (Morris, Brush & Meyers, 2007). In addition to developing systems to support computer-based active reading, several researchers have sought to understand the requirements and phenomena of active reading in the digital environment. Broad studies of active reading have largely focused on why paper tends to support active reading better than computers and digital devices. For example, researchers have suggested that certain academic reading tasks are challenging with digital textbooks. In a diary study that asked 39 students to use the



**Figure 3.1. Active reading generally involves four physical strategies: annotation—highlighting, note taking (Adler & Van Doren, 1972; Pugh, 1978; Adler et al., 1998); reorganization—outlining or summarizing material (Adler & Van Doren, 1972); cross-referencing—working back and forth among documents and/or annotations (Adler & Van Doren, 1972; Pugh, 1978; Adler et al., 1998); and browsing—studying artifacts developed during the other phases (Adler et al., 1998).**

Kindle DX exclusively for reading textbooks, research articles, and other educational materials for a full semester, Thayer et al. (2011) found that many student-oriented goals were not adequately supported by the devices. Specifically, students noted that studying for exams and reading to learn specific topics or information were difficult because “built-in annotation tools are too cumbersome to use regularly” (p. 2921). Among the least desirable features were bookmarking, annotation controls, and highlighting. Learners also articulated difficulties experienced while browsing the text and related annotations.

These themes are pervasive among studies that have similarly explored student attitudes toward using eReaders and tablets for textbook consumption. Doering, Pereira, and Kuechler (2012) used focus groups to explore students’ perceptions in higher education on the awareness, usage, hardware, learning, advantages, and disadvantages of

e-textbooks. They found that college students are “moderately traditional” in their attitudes toward using tablets and eReaders for textbooks because they believe tools intended to aid studying are in need of further improvement before they will be fully accepted and widely used. Similarly, in a 2009 study that provided 240 students at Northwest Missouri State University with all of their textbooks for a semester on the Sony Reader, nearly half of the students surveyed reported they studied less because e-textbooks made studying more difficult (Young, 2009). These findings suggest that further research and development is necessary to conceptualize and build tools that are specifically appropriate for the environments in which they are used. Specifically, tools for annotation and reorganization, as well as designs that better facilitate easy browsing and cross-referencing are clearly called for in the tablet textbook field.

As noted in the previous chapter, the novel and relatively new affordances provided by interactive touch screen tablets – especially those that have surfaced since Apple’s 2010 release of the iPad – have spurred development of new devices and features designed to support active reading. Systems like GatherReader (Hinckley, 2012), Multi-Slate (Chen, Guimbretiere & Sellen, 2012), LiquidText (Tashman & Edwards, 2011b), and the like (all explained in greater detail in Chapter 2) attempt to provide learners with a wider range of interaction techniques designed to facilitate active reading. However, although many of these projects present compelling design ideas, development has largely focused on replicating the properties of paper texts in the digital environment. Likewise, design has mostly been inspired by designers’ insights into what new functionality readers need, as opposed to learners’ actual behaviors and input. This may result in novel ideas and technologies, but it remains unclear whether new systems have truly addressed the functions that learners want and the difficulties they face in their actual active reading tasks.

In fact, there is another concept altogether that has received little attention. How might the design of the tablet textbook itself be reconsidered so that it is better aligned with touch screen tablet interfaces? Furthermore, given that tablet textbooks already increasingly integrate interactive multimedia (Schaffhauser, 2014), how can active reading and studying features be better aligned with that content? This dissertation seeks to answer those questions by first asserting that the active reading features provided by

existing tablet textbook platforms may not be sufficient in digital touch screen environments, especially when it comes to multimedia content. Furthermore, although active reading is fundamental to learning, there is little understanding about whether traditional active reading frameworks sufficiently characterize how learners study multimedia tablet textbooks. And finally, traditional descriptions of active reading aren't always sufficient for expressing what learners are actually trying to accomplish in the interactive digital environment. For example, when multimedia content is seamlessly integrated with narrative text in the context of a tablet textbook, learners must *read* text, *watch* video, and *listen* to audio. Although a great deal of research has addressed audiovisual annotation alone, none has adequately identified key requirements for systems to effectively support active reading in an integrated multimedia environment like the tablet textbook.

However, this is not to say that the original active reading framework is no longer relevant. On the contrary, early definitions of active, responsive, and work-related reading are applicable to the interactive, multimedia tablet environment. However, we must advance our understanding of these structures so they can both inform future research directions and continue to grow and evolve from a strengthened understanding of what it means to read, study, and learn in the digital age. This dissertation seeks to explore how the design of tablet textbooks can better support active reading experiences, processes, and outcomes. To do so, it specifically focuses on the aforementioned “four physical strategies” learners commonly enact to build and analyze annotations meant to help synthesize, comprehend, and understand educational content. These particular activities form the foundation for this dissertation to ground contributions to tablet textbook design in concrete active reading strategies and behaviors.

The chapters that follow chronicle several studies that were all driven by this model, as well as prior characterizations of active reading, as a means for grounding explorations of digital active reading and informing the development of novel active reading support tools. Chapter 4 begins this pursuit by reporting on a preliminary qualitative study that engaged 30 students in active reading with two tablet textbooks. The main purpose for this early work was threefold: 1) to identify and characterizes learner behaviors specific to active reading of a multimedia tablet textbook, 2) to discover

limitations and potential of existing active reading tools, and 3) to envision key requirements for novel systems to support educational active reading in the tablet environment.



## 4 Active Reading Behaviors in Tablet Textbooks

Prior research has established that to date, most tablet textbooks and eReader devices fall short of providing learners with a suitable active reading experience. However, there is little understanding about whether traditional active reading frameworks sufficiently characterize how learners study multimedia textbooks in the tablet environment. Thus, the following questions guided a preliminary exploratory study: 1) Do current characterizations of active reading sufficiently address the key actions learners take when studying a multimedia tablet textbook? 2) What active reading strategies and/or behaviors emerge when learners engage with interactive, multimedia content? 3) What types of tools must be developed for users to achieve all of their active reading and learning goals in the multimedia tablet textbook?

### 4.1 Overview and purpose

To address these questions, a qualitative study engaged 30 students in an active reading experience with two tablet textbook modules. The main purpose for this early work was to discover what, if any, novel study behaviors learners enact that are key to the active reading experience with tablet textbooks. Results from this study illustrate that existing active reading tools do little to support learners when they struggle to make sense of and subsequently remember content delivered in multiple media formats, are distracted by the mechanics of interactive content, and grapple with the transient nature of audiovisual material.

It is important to note that the multimedia tablet textbook can be distinguished from other digital textbooks, such as epub/eBooks, which are more accurately described as interactive PDFs with hyperlinks and basic annotation features. In contrast, a multimedia tablet textbook blends the structure of a traditional book with additional media, such as *audio*, *video*, *animations*, and *interactive graphics*. Valuable user feedback was collected and key deficiencies were uncovered in existing active reading tools that hinder successful multimedia tablet textbook reading experiences. Novel traits of active reading also emerge that characterize tablet-based learning and indicate directions for better active reading support. This preliminary research makes the following contributions:

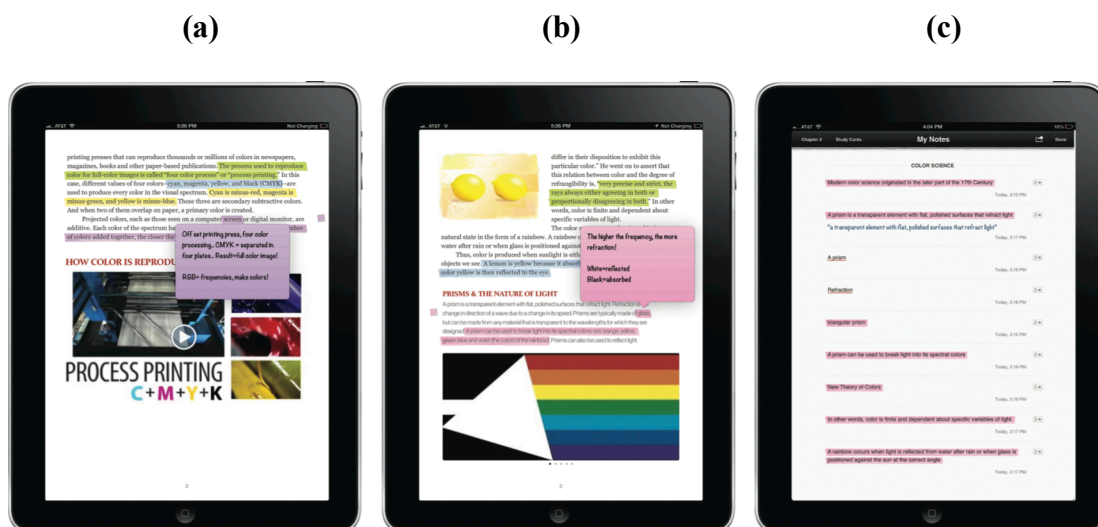
- Identifies and characterizes a set of learner behaviors specific to active reading of a multimedia tablet textbook;
- Discovers limitations and potential regarding the usability of existing active reading tools;
- Envisions key requirements grounded in relevant theories of active reading and multimedia learning for novel systems to better support educational active reading of tablet textbooks.

The following sections outline the study design and report on key behaviors learners enact, which are unique to the interactive, multimedia tablet textbook, as well as share user feedback that will inform future novel designs of active reading tools. This experiment has been approved by IRB #IRB-419378-1.

## 4.2 Study design

### 4.2.1 Setting and stimuli

Participants were exposed to one of two tablet textbook modules. One focused on color theory and included content adopted from a desktop multimedia textbook used in 100-level graphic design courses. The second focused on photosynthesis and replicated content in a 100-level Biology text. Figure 4.1 illustrates the design and structure of the modules. This was not a comparative study. Rather, two modules were used to ensure



**Figure 4.1. Tablet textbook modules included (a) videos/animations and interactive graphics, (b) built-in tools for highlighting and annotation, and (c) a concatenated list of a learners' annotations for future review.**

diverse educational content with the understanding that subject matter could affect perceptions of the experience. Modules included text (approximately 2,500 words), videos and animations (five, two-minute segments per module), and interactive graphics (two per module). Built-in tools, such as highlighting text, saving portions of highlighted text on a separate page, and bookmarking important content were supported. Users could also stop, rewind, fast-forward, and replay audiovisual content and insert annotations near videos. iBooks Author was used to develop the modules. iBooks Author offers all the necessary functionality for simulating typical active reading features offered by other tablet textbook platforms, such as highlighting text, making personalized notes, and reorganizing annotations for future review. McGraw-Hill, Pearson Education, and Houghton Mifflin Harcourt—the world’s leading textbook publishers—all have created iBooks Author titles.

#### **4.2.2 *Participants***

Thirty undergraduate students (aged 18-20; 12 male, 18 female) at Ball State University were recruited from a 100-level mass media course to participate in this study. Participants were given extra credit in exchange for participation.

#### **4.2.3 *Procedure***

After agreeing to participate, individuals were randomly divided into two groups of 15, and each group was assigned one of two tablet-based modules (color theory or photosynthesis). Each participant was invited to attend a 90-minute study session during which they met one-on-one with the researcher. Table 4.1 details study procedures, which were intended to instantiate the condition of a typical study session. An introduction that included information about the purpose and procedures of the study was followed by time to initially study the material, a break from the content, and time to review the material and any annotations or study aids developed during the initial study session. A semi-structured interview about the experience completed the session. This study was not intended to assess learning, but to uncover problems that may emerge during the study process when learners engage in active reading with a multimedia tablet textbook.

<b>Description of Activity</b>	<b>Time (mins.)</b>
<b>Introduction</b> Participants were given an overview of the study purpose and procedures and completed consent forms and active reading and demographic surveys. Participants were also given a brief training session on basic tablet textbook structure and functionality.	<b>10</b>
<b>Study Session</b> Participants were asked to study the module as they typically would for a class reading assignment.	<b>20-30</b>
<b>Break</b> Participants were given a break intended to mitigate fatigue and establish separation between the “study session” and the “review session.”	<b>10</b>
<b>Review Session</b> Participants were asked to review the module and their annotations as they typically would in preparation for a quiz.	<b>15-25</b>
<b>Quiz</b> A five-question, short answer quiz was administered. Open-ended questions mitigated the possibility that participants could guess correct answers.	<b>15-20</b>
<b>Semi-Structured Interview (audio recorded)</b> Interviews included pre-established and follow up questions to elicit feedback about the experience.	<b>10</b>

**Table 4.1. Participants attended a 90-minute study session during which they met one-on-one with the researcher.**

Therefore, no longitudinal retention data was collected. Quizzes were administered to strengthen the study design based on two assumptions. First, because study sessions were not tied to performance in a specific course, it was possible that participants might not have studied as carefully as they would if they were being graded. Thus, by instructing students to study in preparation for a quiz, an actual study session for a class reading assignment could be more effectively simulated. Second, by gauging how thoroughly participants studied the material, as well as what parts of the tablet modules were most memorable, the specific nature of their active reading behaviors could be assessed. Interview questions revolved around participants’ perceptions of usability related to the overall tablet textbook experience, as well as individual active reading features, such as annotating, highlighting, and interacting with video and graphics. A few questions also explored participants’ opinions about the quality of the content they studied, as well as whether they would prefer tablet textbooks to printed textbooks in the future. Appendix A includes the complete protocol used for this study.

#### **4.2.4 Data conversion and analysis**

Three types of data were collected: 1) observational notes taken by the primary researcher, 2) participants' paper notes and frame grabs from tablet annotations and notes, and 3) responses to semi-structured interviews. Qualitative data analysis software was used to code all three types of data.

##### *4.2.4.1 Observational notes*

The observer noted participants' interactions with the device, such as the number of times he/she paused a video to take notes or re-watched a video. Likewise, notes taken outside the device—such as sketching on paper while a video played—were also recorded. Observational notes generated 72 units across 30 participants. A unit was defined as a specific active reading activity, strategy, or behavior observed by the researcher. Each unit of analysis was assigned a code to represent a summative, salient, and/or essence-capturing attribute (Saldaña, 2012). Four key themes emerged from observational notes, which are discussed later. Behaviors observed for at least one-fourth of participants were considered pervasive.

##### *4.2.4.2 Semi-structured interviews*

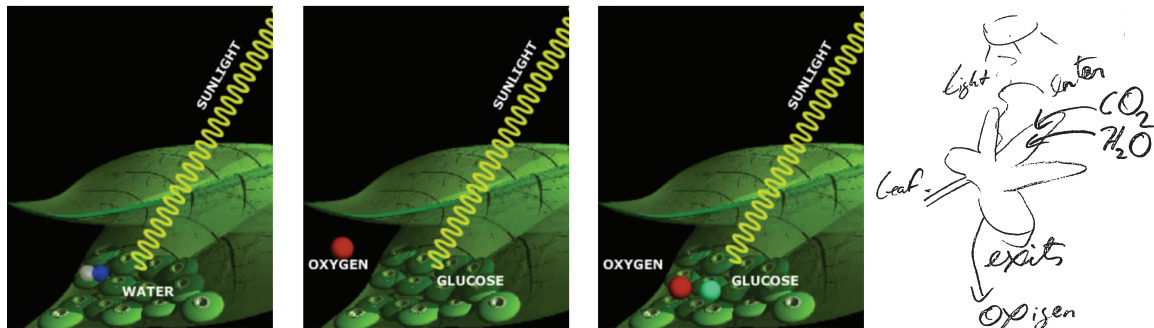
Interviews generated 1,962 units across 30 participants. Transcript analysis included the development of a coding schema designed to illuminate learner behaviors, active reading strategies, and opinions about the active reading experience in the tablet textbook. Each unit of analysis was assigned a code to again represent a summative, salient, and/or essence-capturing attribute (Saldaña, 2012). A unit was defined as any simple sentence or coherent fragment. Units that were similar in nature were grouped under themes that captured the nature of a particular category. The coding schema revolved around observed active reading behaviors and participant comments regarding experience and ease of use, perceptions of the quality of content, how interactivity and multimedia content affected the learning process, additional strategies used to annotate and take notes (e.g., use of paper), and study habits. Table 4.3 (in the results section) shows the complete coding schema and illustrates the number of participants who made one or more statements related to an individual code.

#### 4.2.4.3 Participant annotations

Paper notes and frame grabs were analyzed using a standard artifact analysis method to provide a qualitative interpretation of the general properties of notes (Given, 2008). Artifacts were analyzed for general content and organization. Similar artifact observations were grouped together and counted. A total of 16 pages of written notes and 231 pages of in-text frame grabs were collected. Finally, responses to quiz questions were evaluated for accuracy. Answers were coded as *correct*, *incorrect*, or *partially correct* (a portion of the correct answer, but still lacks completeness).

### 4.3 Results

Four key behaviors were identified as a result of the analysis of observational data and artifacts generated during study sessions: 1) sketching video frames, 2) recalling animation mechanics rather than accurate content, 3) integrating concepts embedded in multimedia with notes drawn from other sources, and 4) struggling with the tension between operating audiovisual content and the active reading experience. The following sections describe these behaviors and include relevant interview responses and observational notes. Additional themes that emerged from post-session interviews are also included in this results section.



**Figure 4.2. Sketching video frames: Participants often combined several frames of an animation into a single sketch.**

#### 4.3.1 Observed behaviors

##### 4.3.1.1 Sketching video frames

Participants frequently made sketches on paper while watching videos and animations in an attempt to replicate the visual frames in their notes. Moreover, participants often tried to combine several frames of an animation into a single sketch.

According to one participant [P22], “Sketching helps me work through the information on my own. I think it helps me remember the information better; but actually making the sketch helps too. It helps me understand it as I sketch it.” Another participant [P8] noted that, “I like the videos. It’s good to have the visual and the action to help me study and remember. But the more complicated videos [and] processes are hard to wrap my mind around because they are moving so fast. Sketching helps slow it down in my head.”

Figure 4.2 illustrates how one participant tried to capture in a single sketch the substance of about 12 seconds of a 90-second animation explaining the chemical conversion during photosynthesis. Eleven other participants engaged in similar sketching strategies, integrating these sketches with the rest of their notes.

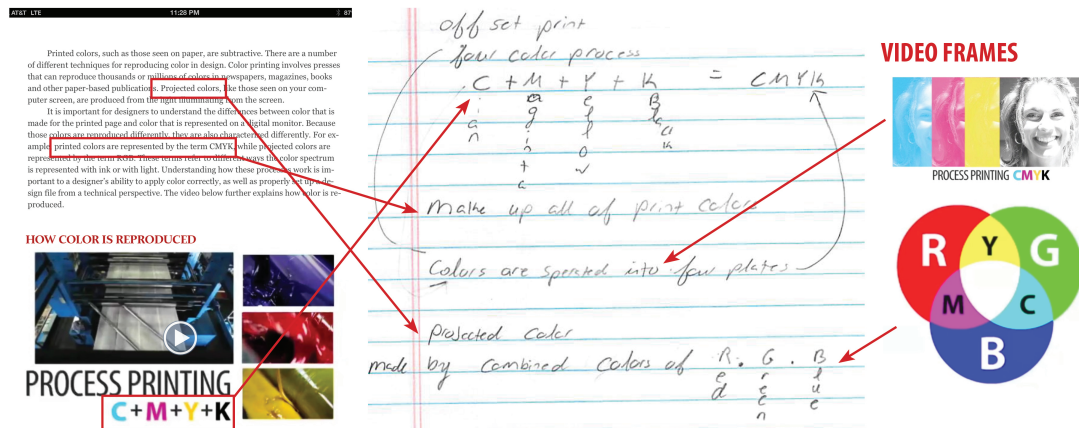
#### 4.3.1.2 *Recalling animation mechanics rather than accurate content*

Quiz results indicate that when answering questions drawn from videos and animations, participants often tried to describe what they remembered seeing in the visual sequences. However, many fell short of rendering a complete or accurate response. For example, regarding the quiz instructions, “Explain the process of photosynthesis,” one participant rendered the following response:

*Photosynthesis is the process of sunlight reaching a plant to convert water and carbon dioxide into glucose and oxygen. The sunlight enters the plant and scatters the carbon dioxide and water to separate into the other two produced afterwards. Photosynthesis gives the plant energy to complete tasks by creating sugars [P17].*

The first three frames of Figure 4.2 represent key frames of the central video that describes the process of photosynthesis. Although this participant’s response is off to a good start in the first sentence, it begins to wander off as the participant clearly has trouble remembering all of the important visual steps in the photosynthetic process. Likewise, one participant who studied the color theory unit indicated that prior to taking the quiz, she felt confident that she understood the material. However, when trying to recall the specifics of the four-color printing process, she struggled to recall the exact details well enough to feel confident with her answer. “When I was watching, I felt I understood the concept,” she said. “But then, when I had to describe it myself, I remembered what I saw, but not really exactly what I heard. It was hard to explain”

[P29]. In these cases, learners seemed to remember the general mechanics of a concept that was illustrated in an animation but had a less firm grasp on the descriptive contents of the related narrative. In this sense, audiovisual content was often elusive to learners when they tried to recount what they saw or heard in the context of an exam.



**Figure 4.3. Annotating connections among notes and media formats: Participants created personally meaningful outlines that included lines and other symbols to connect concepts and notes to media formats.**

#### 4.3.1.3 Integrating concepts embedded in multimedia with notes from other sources

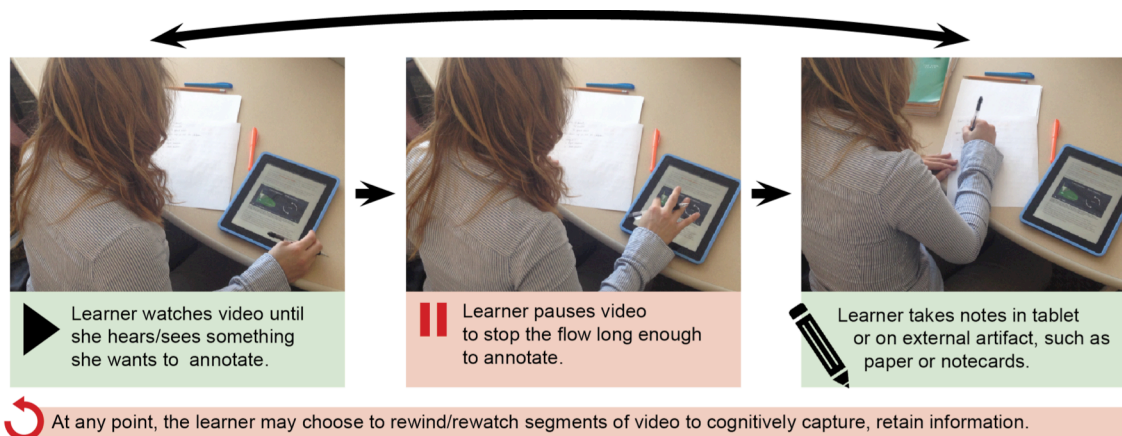
About one-third of the participants (n=11) took notes on paper to avoid using the tablet keyboard. Eight abandoned the tablet annotation tools altogether in favor of the paper method. Moreover, most of them developed strategies for connecting related concepts, as well as including tags within their notes to identify the format (i.e., video, animation, text, audio, etc.) in which a particular segment of information was originally presented. Participants who took notes on paper often tried to diagram and/or outline information in more personally meaningful ways than the system allows. For example, several participants reorganized their notes into the form of an outline of the chapter, pulling together concepts they perceived to be related, regardless of the order in which they originally appeared in the tablet module. Furthermore, several participants drew additional annotation marks to indicate when concepts in their notes were in some way connected, such as arrows, lines, circles, etc. Figure 4.3 illustrates this strategy. To explain why she did this, one participant said, “I need to be able to put things in my own words and sort of show myself how things go together in my notes. This is really



important. These little lines and circles are meaningless to someone else. But to me, they have meaning and help me remember [and] understand” [P13]. Participants also frequently marked their notes to indicate what type of media format was used to deliver the information. This strategy represented a form of internal cross-referencing across information and media types. For example, one participant marked notes that were drawn from videos with a “v”, notes drawn from text with a “t”, and so on. The participant explained this by saying, “If I can recall where I first saw it, it’s easier for me to remember more of the information later. Since there are so many different formats here, it’s good to keep track of where everything came from” [P1]. Thirteen participants engaged in similar tagging schemes to remind themselves the media type with which a particular annotation was associated. Again, when reviewing notes to prepare for the quiz, most of the participants who engaged in this behavior only reviewed their sketches and did not return to the actual tablet for review.

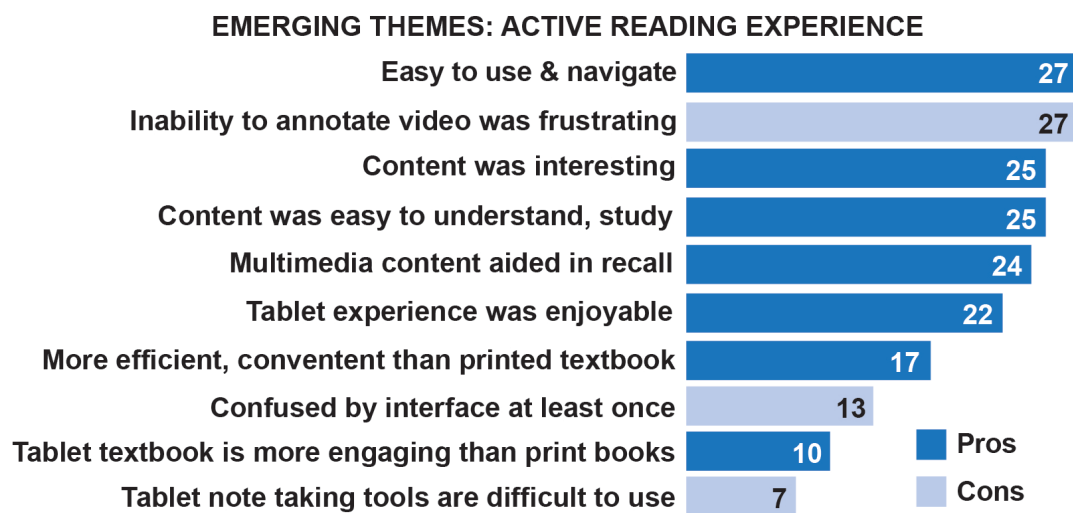
#### 4.3.1.4 *Struggling with tension between operating audiovisual content and the active reading experience*

More than two-thirds (n=22) of participants engaged in the cumbersome process of frequently pausing, rewinding, and re-watching videos several times in concert with their note taking activities. However, it is important to decouple active reading behaviors,



**Figure 4.4. Struggling with tension between operating audiovisuals and learning:**  
**To annotate video, learners must either: 1) write notes while a video plays, requiring split attention between listening, watching, and writing, or 2) stop the flow, by pausing the video while writing notes. They may also rewind and re-watch a video multiple times to capture all of the necessary information in a single annotation.**

such as note taking and highlighting, from the mechanics of the interface. In fact, stopping, replaying video, and the like represent an interruption of the active reading flow. As shown in Figure 4.4, participants often watched video until they wanted to take notes. Then, they had to pause the video before taking notes so as not to miss audiovisual content that would continue to play while they were looking away from the video. Additionally, many participants rewind and re-watched videos or portions of videos more than once (some as many as five times). Other participants simply took notes while the video continued to play. Some rewind and re-watched content they missed while looking away; others did not, potentially missing important information. By way of example, during a five-minute interaction with a 40-second video, one participant paused the video nine times to take notes, rewind the video to re-watch a portion of it four times, and restarted the video to re-watch the entire segment three times. This mechanical interaction often represents a distracting or even disorienting break in the active reading flow. One participant voiced this concern: “I really love the animations. They are interesting beautiful. They are much more interesting than reading this information. But I have to spend so much time messing with the buttons. I had to rewind a lot. I couldn’t always remember what was said so that I could write my notes quickly. It was sort of hard...sort of clunky” [P19]. Table 4.2 (on the following page) defines emergent themes and aligns each to the data sources from which they were derived.



**Figure 4.5. Feedback on general tablet textbook experience**

### 4.3.2 Additional themes that emerged during interviews with participants

#### 4.3.2.1 Tablet textbook was easy to use and convenient

Overall, participants reported the tablet textbook was enjoyable and easy to use and navigate. Figure 4.5 (on the previous page) illustrates key themes that emerged related to the general active reading experience. More than half said the tablet textbook was more efficient, convenient, and/or organized than print textbooks; and some said they found the tablet textbook to be more engaging than previous experiences with printed textbooks. Likewise, most participants reported tablet content was easy to understand and study. On the other hand, nearly half reported being confused or frustrated by some aspect of the interface at least once, with most complaints in reference to a lack of familiarity with touch screen gestures for annotation. Nearly all (n=25) were frustrated by

<b>Emergent Themes</b>	<b>Characterization</b>	<b>Data Sources</b>
Challenging content-to-format mapping	Integrating concepts embedded in multimedia with notes from other sources	<ul style="list-style-type: none"><li>• Observed behaviors</li><li>• Participant annotations</li></ul>
Transient & elusive nature of audiovisuals	Sketching video frames	<ul style="list-style-type: none"><li>• Observed behaviors</li><li>• Participant annotations</li></ul>
Distracting mechanical interaction	Struggling with tension between operating audiovisual content and active reading experience  Recalling animation mechanics rather than accurate content	<ul style="list-style-type: none"><li>• Observed behaviors</li><li>• Participant annotations</li><li>• Quiz responses</li></ul>
Tablet textbook was easy to use and convenient	General tablet textbook experience was positive	<ul style="list-style-type: none"><li>• Interview responses</li></ul>
Perceptions of annotation and highlighting were mixed	Annotating text was easy, while annotating audiovisuals was inefficient and/or ineffective	<ul style="list-style-type: none"><li>• Interview responses</li></ul>
Breakdowns existed in browsing and operating system mechanics	Important contextual connections are lost when annotations over all content are viewed as a list; typing is cumbersome	<ul style="list-style-type: none"><li>• Interview responses</li></ul>
Perceptions of annotation notebook features and functionality were mixed	Concatenated annotations is convenient but format of annotation notebook is ineffective	<ul style="list-style-type: none"><li>• Interview responses</li></ul>

**Table 4.2. Descriptions of emergent themes aligned with data sources**

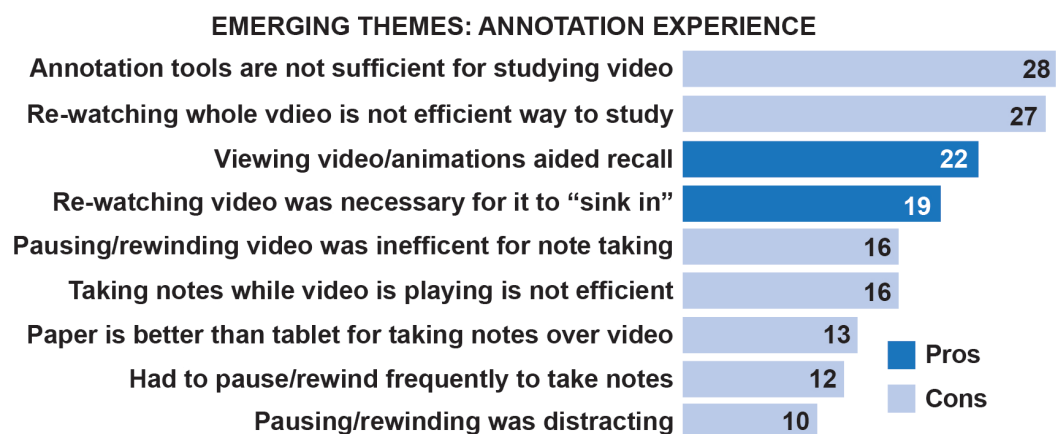
<b>Feedback gathered during participant interviews</b>	<b>Percent Occurrence</b>	<b>N=P</b>
<b>Operating Tablet Textbook: General Interface Mechanics</b>		
Tablet was easy to use, navigate	90%	27
Tablet was more engaging than printed textbooks	33%	10
Tablet is more efficient, convenient, organized than print text	57%	17
Tablet experience was enjoyable	73%	22
Tablet interface was confusing at times	43%	13
Tablet experience was not enjoyable	7%	2
Some parts were enjoyable; others were not	20%	6
<b>Active Reading Mechanics Ease of Use:</b>		
The mechanics of the active reading tools were distracting	33%	10
It took a few minutes to get used to the active reading features	43%	13
Had to pause and/or rewind video too frequently	40%	12
Annotation of text was easier on tablet than printed textbooks	53%	16
Annotation of text is easier in printed textbooks than on tablet	3%	1
Color coding highlights helps organize information	17%	5
Seeing annotations all in one place makes them easier to study	57%	17
Tablet note taking tools are difficult to use, ineffective	32%	7
Lack of video annotation tools was not a problem	10%	3
Lack of video annotation tools was frustrating	90%	27
Paper is better than tablet for annotation/note taking	43%	13
<b>Content Recall and Cognitive Processing</b>		
Multimedia helped remember/recall information	73%	22
Video aided concentration, focus, attention, interest, recall	80%	24
Video is more engaging, informative than text, still images	43%	13
Had to re-watch video for it to sink in	63%	19
Re-watching video is an effective way to study	10%	3
Re-watching video is not an effective way to study	90%	27
Static text and/or still images are easier to follow than video	27%	8
Tablet content was easy to study	83%	25
Tablet was difficult to study	17%	5
It was difficult to make connections among annotations in the tablet environment	50%	15
Putting content “into my own words” aids understanding/recall	47%	14
Reorganizing content aids understanding/recall	17%	5
Writing on paper aids recall	40%	12
Videos did not keep concentration, focus, attention, interest	20%	6
<b>Overall Quality of Tablet Textbook Content</b>		
Content is interesting, easy to understand	83%	25
Content was not interesting, easy to understand	17%	5

**Table 4.3. The coding schema was designed to illuminate learner behaviors, active reading strategies, and opinions about the experience. This table offers a summative picture of the most common and/or significant themes that emerged.**

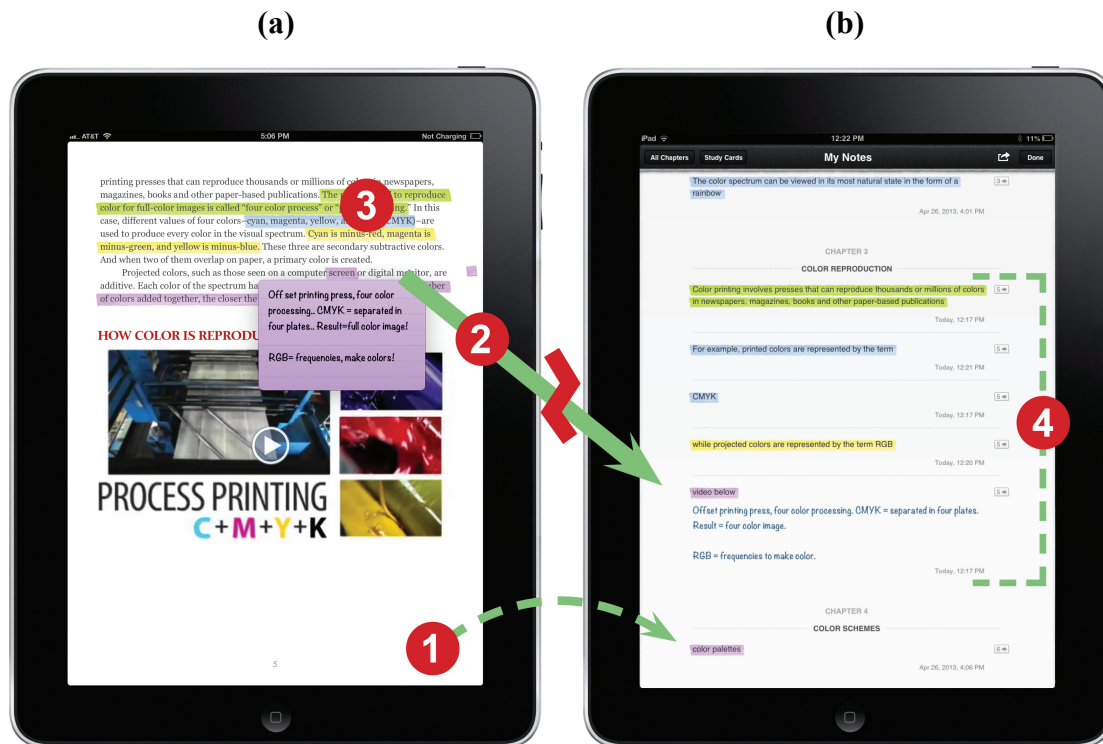
the limited ability to annotate videos and animations. Yet, most (n=27) reported that in the future they would prefer tablet textbooks, citing convenience, interactivity, and multimedia as attractive features for learning. Table 4.3 (on the previous page) shows the complete coding schema and illustrates the number of participants who made one or more statements related to an individual code. Furthermore, to clearly categorize participants' feedback, additional responses can be matched with the four most common active reading strategies: annotating, cross-referencing, reorganizing, and browsing.

#### 4.3.2.2 *Perceptions of annotation and highlighting were mixed*

Feedback regarding annotation was mixed, depending on whether participants referred to highlighting and note taking over text-based content or audiovisual content. *Annotation of text-based content* was characterized as easier on the tablet than in printed textbooks for about half of the participants (n=16). Similarly, about half reported that the ability to see all annotations in one place makes it easier to study (n=17). At the same time, about a quarter (n=7) said the tablet note taking tools are difficult to use. *Annotation of audiovisual content* did not fare well among most participants, who said existing tools were insufficient. Most participants said viewing video, animations, and visualizations helped them recall information better than reading text. But most also said re-watching video over and over again, pausing/rewinding the video frequently to take notes, and/or trying to take notes while the video is playing without stopping/rewinding are not efficient or effective ways to study. Figure 4.6 shows a complete summary of participant feedback regarding annotation of video.



**Figure 4.6. Feedback on video annotation experience**



**Figure 4.7. Four main breakdowns challenged learners' active reading process.**

#### 4.3.2.3 Breakdowns existed in browsing and operating system mechanics

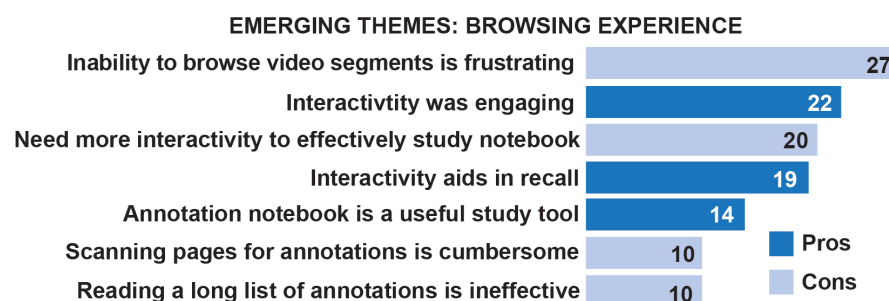
Half of the participants reported that it was difficult to make connections among annotations, notes, and/or pages or segments of content. They also indicated that although the tablet notebook shows promise as a method for concatenating annotations (Figure 4.7b) made with the textbook's built-in tools, it is not as easy to study as it could be. They cited four specific challenges visualized in Figure 4.7.

1. The fact that users could only see one page at a time makes it hard to "flip back and forth" among multiple pages (n=15). As a result, learners struggle to efficiently cross-reference annotations (made both on paper and within the tablet textbook environment) with the original source material in the body of the text. This complaint is consistent with prior research (O'Hara, Taylor, Newman, & Sellen, 2002) that suggests that traditional books provide an important visceral affordance by allowing learners to quickly scan through a number of pages and maintain a sense of orientation with their progress through a chapter and pages of content in relation to one another.

2. Important context and conceptual connections are lost when annotations are viewed as a list, organized in the order they were made and separate body of the chapter (n=12). For example, highlighting a single word or sentence fragment is common practice among learners studying a traditional print text. However, in the tablet environment, highlights typically appear isolated in the digital notebook (illustrated in Figure 4.7b), completely separate from the originating page. As a result, individual highlights are rendered useless, as it is often difficult for learners to remember the specific significance of a highlighted word or phrase when it is taken out of context. A learner can tap a button to return to the page on which the highlight appears. However, this action subsequently takes them away from the notebook and out of the flow of reviewing notes. This can be both disorienting and cumbersome.
3. Typing is more cumbersome than writing. Thus, taking notes on paper is easier than doing so with the tablet keyboard (n=12). Participants voiced that it was much easier and faster to write notes on paper than it was to use the tablet keyboard.
4. When notes taken over audiovisuals are combined with notes from text-based content, it is difficult to mentally map content to its original source (n=11). For example, when a learner adds a personalized note to the text, the note is generally “attached” to specific content, such as a paragraph of text or a whole video. However, when the learner reviews a collection of notes in the notebook, each annotation appears by itself, with no specific reference to the content it was originally attached to. Thus, in order to review often-important contextual information, the learner must tap a button to return to the originating page, leaving the notebook entirely. Additionally, existing tablet textbook formats, like Inkling and iBooks Author, only allow the learner to attach notes to a video, but not to individual points within that video. Thus, although a learner may have multiple notes associated with a single video, there is no way to discern what part of a video each individual note references during a review session. These issues can be both disorienting and confusing when learners are trying to remember the significance of an individual annotation.

#### 4.3.2.4 *Perceptions of annotation notebook features and functionality were mixed*

At present, two main methods for studying annotations and outlines are supported in most tablet textbooks. The first is the act of scanning previously read pages in search of annotations. The second is scanning the automatically generated list of annotations made by the learner during the initial read-through. About half of the participants reported that the annotation notebook was a useful tool. However, nearly all articulated frustrations with the notebook, citing difficulty browsing video annotations (n=27) and reading a long list of annotations (n=10) with little to no hierarchy or structure as frustrating and/or ineffective. Furthermore, upon completing the quiz, a third of the participants said that scanning pages for annotations and/or reading over a collection of annotations was less effective than they thought it would be for helping them remember what they read. Most participants said more interactivity during the studying portion of study would be more effective. In fact, participants were largely in favor of any feature that allowed them to interact with the device, noting that interactivity was engaging and aided in recall. Most participants likened interactivity to the same type of cognitive processing that occurs when writing notes, putting material “in my own words,” and outlining a significant section of content. Figure 4.8 offers a complete summary of participant feedback regarding browsing annotations and notes.



**Figure 4.8. Feedback on browsing annotations and notes**

#### 4.3.2.5 *Participants' suggestions for video annotation*

When participants expressed frustration with the challenges they faced when studying audiovisuals, they were asked to suggest tools that might be useful to them. The following suggestions were offered by at least half of the participants:



- Provide multiple mechanisms for marking, annotating, reorganizing, and browsing video and audio segments.
- Provide more interactive features in addition to pause, fast-forward, and rewind that allow users to engage more actively with videos and animations.
- Provide learners more freedom to act on videos in ways that help facilitate recall.
- Provide tools that allow learners to more easily make connections among annotations, especially when those annotations come from multiple media formats.
- Make the mechanics of operating interactive elements (like video control buttons) more transparent and less of a distraction.

#### **4.4 Discussion**

The behaviors and participant feedback identified in this study provide insights into how we might begin to evolve characterizations of active reading in the tablet textbook environment, as well as provide better active reading support for multimedia content. Specifically, improving functionality that facilitates the “four physical strategies” learners enact to build and analyze artifacts for studying—annotation, reorganization, cross-referencing, and browsing—should be a primary concern. However, this effort must be grounded in the core principles of both Active Reading and Multimedia Learning Theory to ensure that novel designs are grounded in established guidelines for effective learning. The sections that follow explore possible directions for this evolution in the context of the goals and results from this study, as well as existing conceptions of those four foundational active readings activities.

##### **4.4.1 Research questions revisited**

###### **4.4.1.1 RQ1: Do current characterizations of active reading sufficiently address the key actions learners take when studying a multimedia tablet textbook?**

Although learners clearly engage in annotation, reorganization, cross-referencing, and browsing activities in the tablet environment, these activities are influenced in significant ways by tablet textbook mechanics and built-in features meant to aid studying. This was especially evident when text, audio, video, and other multimedia content on a

single topic were combined in one learning module. In this case, active reading is deeply intertwined with interactive system mechanics requiring more than simple acknowledgement of the digital device as a tool. Rather, results suggest that differences in the ways users engage with content—i.e., read, watch, listen, rewind, save, highlight, type, etc.—can be as distracting as they are engaging. In fact, mechanical interaction with the device may present a split-attention affect in which a learner’s focus on studying is limited by the need to operate the device. As a result, although annotating, reorganizing, cross-referencing, and browsing are still relevant, their application is more complex in the tablet textbook.

*4.4.1.2 RQ2: What active reading strategies and/or behaviors emerge when learners engage with interactive, multimedia content?*

Results from this research identified key behaviors learners may enact when studying a tablet textbook. These strategies represented one of two themes: 1) adapting familiar active reading strategies to audiovisuals (*sketching video frames* or *integrating concepts embedded in multimedia with notes drawn from other sources*) or 2) toiling with the mechanics of audiovisual content (*recalling animation mechanics rather than accurate content* or *struggling with the tension between the operation of audiovisual content and the learning process*). Furthermore, interview results confirm some specific challenges learners face when balancing the learning process with tablet interaction. This tension between learning and engaging with a tablet textbook must be minimized for learners to have efficient and satisfying active reading experiences. The sections that follow illuminate the most important themes related to the balance between learning and interaction mechanics. Additionally, we return to the cognitive theory of multimedia learning to inspire novel designs that may better support active reading.

*4.4.1.3 RQ3: What types of tools must be developed for users to achieve all of their active reading and learning goals in the multimedia textbook?*

An effective tablet textbook must support learners’ complete active reading needs with built-in tools that minimize distraction and maximize utility and active engagement with content. Annotation tools must allow learners to mark and/or otherwise save content they wish to revisit efficiently and in ways that make sense to them. Additionally,

learners may require new and/or different features for marking video, audio, and animations due to their transient nature. Furthermore, because annotations can be automatically concatenated in the digital space, the design for those reorganized annotations needs better structure and information architecture to be personally meaningful for learners. Moreover, explicit cues that indicate the media format from which an annotation originated, as well as other types of tagging and filtering capabilities may better support the internal cross-referencing of annotations that occurs when notes are derived from different media formats. Finally, both the built-in annotation tools and the organization of annotations made by learners must support easy browsing by mitigating the breakdowns that may occur in the one-screen, touch-screen environment. In other words, in the absence of a physical book with pages to flip through, alternative methods must be devised for aiding learners in physical orientation (i.e., “where am I in the text?”) and cognitive orientation (i.e., “how do concepts connect?”). The sections that follow explore the findings from this study through the lens of the cognitive issues associated with active reading and point to some possible directions for future work.

#### **4.4.2 Challenging “content-to-format mapping”**

Content-to-format mapping of multimedia can be defined as a learner’s attempt to stimulate memory by making notes not just about the content but about the type of media from which an annotation was derived. This finding would confirm prior research in multimedia learning. According to Mayer (2009), even the simplest forms of multimedia learning represent “a demanding process that requires selecting relevant words and images, organizing them into coherent verbal and pictorial presentations, and integrating the verbal and pictorial presentations with each other and with prior knowledge” (p. 75). Thus, it stands to reason that the interactive tablet textbook represents a heightened level of complexity by integrating content delivered in several media formats and designed as a browse-able book. One way participants attempted to cope with this complexity was observed as *integrating concepts in multimedia with notes drawn from other sources*. Participants often marked their notes in an effort to trace ideas, concepts, and key segments of information back to the media format in which it was first encountered. Some users also made markings to indicate that concepts from different segments of a

chapter relate to one another. This strategy represents a form of mental processing articulated as a need to mentally connect information to the media format in which it was delivered to aid recall.

The fact that learners struggle to remember content delivered in this integrated multimedia book-like format suggests that existing tablet textbooks may create an increased demand on cognitive load during the textbook reading and studying process. Although participants may have expressed that the tablet textbook *was easy to navigate and operate* in a general sense, this sentiment doesn't necessarily translate to *easy to study* (or easy to recall) when it comes to employing active reading and learning strategies. Moreover, the breakdowns illustrated in Figure 4.7 further illustrate challenges participants faced in making connections and cross-referencing information among annotations, both across all notes and between information presented in different media formats. Ultimately, this may make it difficult to migrate from print texts to their multimedia tablet counterparts. The behaviors—both physical and cognitive—that learners use to mentally organize what they learn in the tablet textbook are not only different, but potentially more complex than those developed for print textbooks and singular audiovisual presentations.

#### **4.4.3 *Transient and elusive audiovisual content***

One key behavior observed while participants were engaged in active reading—*sketching video frames*—demonstrates that learners struggle with the transient nature of audiovisual content. For example, moving animations—while highly visual and explanatory in nature—are also comprised of sequential images and audio, which are gone from view as quickly as they first appeared. Because of this, any attempt to carefully study audiovisual content is thwarted by its very nature. Not only is it difficult for students to maintain focus, the transient nature of audiovisual content is such that the focus of the content is constantly changing. This was evidenced when participants tried to counteract the dynamic nature of moving pictures and audio by freezing it in the form of a single sketch. This finding is consistent with scenarios outlined in the Cognitive Theory of Multimedia Learning, which notes that “in viewing a fast-paced narrated animation that explains the steps in a process, some learners may not fully comprehend one step in

the process before the next one is presented, and thus, they may not have time to see the causal relation between one step and the next” (Mayer, 2009, p. 175). This observed behavior suggests an interesting dichotomy regarding whether still images or videos/animations are more effective for delivering a sequence of visual information. While the dynamism of a video may be more engaging to *consume*, the static nature of the still image may be easier to *study*. Alternatively, the dynamic and transient nature of video may make it more difficult to quickly synthesize and capture information for the purpose of annotation, while the concrete and static nature of still images (and text, for that matter) are easier to annotate.

#### **4.4.4 *Distracting mechanical interaction***

Video annotation seems to be complicated further by complex mechanical interaction, which may cause watching and annotating audiovisual content to be potentially distracting and cumbersome. This tension was reflected in both the observed behavior *struggling with the tension between the operation of audiovisual content and the learning process* and the most common frustrations participants expressed during interviews. Unlike a printed book in which page turning and writing with a highlighter or pen represents the bulk of the interactivity, the tablet textbook requires more interaction. Active readers in this environment also must enact a complex set of system mechanics necessary for annotating and otherwise interacting with the textbook. Although a few video annotation systems allow users to annotate online video by inserting notes onto a timeline (e.g., iTunes U or Video ANT), none addresses the stress between the amount of attention learners must devote to mechanical interaction and whether the content is actually “sinking in.” Likewise, tablet textbooks require additional mechanical interaction—such as tapping and dragging to highlight or typing to add notes—requiring learners to engage with a wide variety of interaction patterns. In short, all that time spent tapping, swiping, pausing, rewinding, and re-watching pulls learners away from focusing on the information.

#### ***4.4.5 Implications for active reading tools***

##### ***4.4.5.1 Rethinking annotation and highlighting***

Annotating video is physically and cognitively different from annotating text. Thus, a few key requirements arise for future active reading tools that support the “four physical strategies” most commonly enacted during active reading: annotation, reorganization, browsing, and cross-referencing. These requirements are based on the findings from this preliminary study, and rooted in Active Reading literature and relevant principles of the Cognitive Theory of Multimedia Learning, which to date has been limited to individual audiovisual presentations. Annotation systems should be flexible, allowing learners to choose from a number of ways to annotate and review. For example, learners could be provided with a mechanism for annotating a text-based transcript accompanying a video. This could provide a more concrete reference for studying annotations and accessing video segments that correspond to points in the transcript. This concept could be viewed as contradictory to the redundancy principle of multimedia learning, which states that people learn better from graphics and aural narration, rather than graphics, narration, and text (Mayer, 2009). However, Kalyuga, Chandler, and Sweller (1999) found that the redundancy principle applies only when text and audio are presented concurrently. Thus, a transcript that is accessible to a learner after the video has been watched at least once could provide learners with a more concrete reference for studying integrated multimedia content. Additionally, the system could allow learners to extract short segments of a longer video that they can access and reuse during a subsequent study session. With more options for video annotation, learners have more opportunities to assert personal preferences on the active reading experience. This concept is consistent with the segmenting principle of multimedia learning, which states, “people learn better when a multimedia message is presented in learner-paced segments rather than a continuous unit” (Mayer, 2009, p. 175).

##### ***4.4.5.2 Improving core study tools***

Cross-referencing, reorganizing, and browsing represent the bedrock of active reading. Yet, existing tablet textbook platforms—such as iBooks Author, Inkling, and Kno, to name a few—typically reorganize notes into a long list. These designs exist in

spite of the fact that according to multimedia learning theory, meaningful multimedia learning depends on building connections between mental representations of corresponding words and pictures (Mayer, 2009). Likewise, results from this preliminary research suggest that the current design paradigm for concatenating a learner's annotations and notes in a multimedia tablet textbook may not sufficiently help learners study those annotations later. In the list format, it is often difficult for learners to make sense of their notes as study aids. Furthermore, the list structure contradicts the very fabric of active reading, which requires that learners be able to make connections among various types of annotations, as well as review and organize notes in a personally meaningful format. Thus, outlining tools should be more robust. For example, learners should be able to see annotations in a format that visually illustrates how concepts pulled from various places or media types are related. This feature could help users isolate important information while keeping contextual cues intact, allowing learners to more quickly make sense of their notes and review them for future recall.

#### *4.4.5.3 Key requirements for novel active reading support*

Based on the findings from this study, the following key requirements for improving the active reading experience in the tablet textbook environment have been identified:

**R1:** Develop new annotation tools that better support active reading goals as applied to audiovisual content. For example, a novel active reading system for tablet textbooks could enable learners to extract smaller segments of a video, video frame grabs, or key terms mentioned in the video for future review.

**R2:** Provide more concrete ways to access important information presented in the often transient and elusive audio format. For example, novel systems could provide transcripts or other textual content to provide learners with concrete reference points for information delivered in narrative audio.

**R3:** Improve the organization of annotations so learners are more easily able to recall the original source format (i.e., audio, video, text, etc.) of an individual note and make conceptual connections among notes that have been combined into a study guide. For example visual cues and enhanced filtering capabilities would allow learners to

organize and access their annotations multiple ways, potentially providing them with more context than a long list of annotations merely organized in the order they were made.

**R4:** Provide tools that allow learners to achieve their active reading goals (i.e., annotation, saving portions of the text for future review, etc.) without taking them out of the flow of learning, which involves careful attention for effective consumption and comprehension of educational material. For example, a novel system could provide annotation tools that take advantage of touch-screen mechanics but that also minimizes the number of taps, swipes, or other interactions that do not contribute to learning.

These requirements are important considerations for designers who wish to develop active reading that bridge the gap between current paper and pen technologies and emerging digital textbook environments.

#### ***4.4.6 Limitations of preliminary findings***

Subject matter alone could affect a student's perceptions of the tablet textbook experience. Likewise, some content may be more suitable for studying active reading behaviors than others. These concerns were addressed for the present study in a few key ways. First, two different modules of vastly different subject matter were implemented to ensure some degree of content diversity. Second, several segments of audiovisual content were used to trigger a variety of active reading behaviors. Third, both the design of a typical tablet textbook and the typical active reading study session were emulated as closely as possible. Together, these aspects of the research design allowed for the collection of valuable insights to better understand active reading in this environment.

### **4.5 Summary of contributions of preliminary research**

Active reading is fundamental to learning. However, our understanding of active reading is currently tethered to traditional print and paper and pen activities. This preliminary research uncovered empirical evidence that current tablet textbooks could hinder learners' active reading experiences, as well as force them to enact potentially cumbersome or inefficient strategies to achieve their active reading goals. Specifically, this early work characterized some of the challenges learners face as they grapple with



the mechanics of operating the tablet, struggle to effectively annotate sequences of information delivered in audiovisual content, and labor to cognitively make connections between annotations and the source content/media format from which they originated. All of these challenges present potentially detrimental distractions from learning. Overall, this exploratory, qualitative study sheds new light on the nature of active reading with tablet textbooks by uncovering evidence of both usability and cognitive processing problems. Ultimately, these findings elucidate directions that are crucial to understanding next-generation active reading tools and tablet textbook design.

Chapter 5 further explains the rationale, conceptual design, and information architecture for SMART Note, a suite of novel annotation and study support tools. Specifically, SMART Note seeks to provide annotation tools that are easier to use and more efficient than existing systems, particularly where audiovisual annotation is concerned. Likewise, SMART Note provides a more robust annotation notebook with an eye toward improving learners' ability to study and remember important information. Subsequent chapters also chronicle iterative design and usability testing of the SMART Note features, as well as comparative studies that explore how SMART Note stacks up against existing tablet textbook platforms in terms of efficiency, usability, active reading experience, and learning outcomes.

## **5 SMART Note: Student-Centered Multimedia Active Reading Tools**

Annotating in the interactive tablet environment is clearly a different proposition than annotating in the traditional print environment. One significant reason for this dissimilarity is that the most robust tablet textbooks seamlessly integrate traditional narrative text with multimedia content, such as videos, audio, interactive graphics, animations, and image galleries. Granted, this concept is not entirely new, as digital textbooks and web-based multimedia learning modules have been in circulation for many years. However, the tablet device combines the portability, look, and design of a traditional book with the rich multimedia potential of the digital arena.

Thus, the tablet textbook has emerged as a unique technology in its own right and is a potential game-changer when it comes to the way students learn and instructors teach. This dissertation introduces SMART Note, which is envisioned as a suite of multimedia annotation tools for tablet textbooks that integrate traditional narrative text with interactive, multimedia content.

### **5.1 Rationale**

Existing tablet annotation and study support tools available in learning environments may only scratch the surface when it comes to studying multimedia content – namely video – in the context of a browse-able tablet textbook. Like many transitional media environments, existing annotation and study support tools for tablet textbook are generally designed to mimic behaviors learners commonly enact when engaging with a traditional print text. For example, learners can highlight by dragging a finger over text. Likewise, most existing tablet textbooks offer support for self-assessment through interactive quizzes and/or the ability to make browse-able lists of notes. The practice of mimicking known tools and/or behaviors can be an effective way to acclimate learners to the new digital environment. However, the learner experience with tablet textbooks is markedly different than it is with traditional printed texts or even textbooks designed for computer interaction. For example, the seamless integration of multimedia content alone has the potential to alter the reading and learning experience considerably.

To address these concerns, SMART Note includes features meant to improve two main aspects of the active reading experience. First, SMART Note allows learners to

enact several different annotation strategies that minimize interaction with the device. Cumbersome interaction mechanics often distract users from content and take attention away from the flow of learning. Second, SMART Note offers more concrete reference points for mentally mapping a collection of annotations back to their original media sources. When content is presented in multiple media formats, it may become difficult for learners to mentally map individual annotations back to their originating source. The ability to connect annotations to their originating sources is important for effective recall of information.

Ultimately, the tensions between learning and engaging with a multimedia tablet textbook must be minimized for learners to have efficient and satisfying active reading experiences. SMART Note is designed to help learners to achieve their goals while mitigating challenges faced when interactivity and multimedia are integral parts of studying.

## **5.2 Conceptual design**

The SMART Note design was inspired by The Cognitive Theory of Multimedia Learning (explained in Chapter 2) and results from the exploratory study chronicled in Chapter 4. Furthermore, results from iterative design and usability research (reported later in this chapter) rounded out the informed development of the SMART Note prototype. This user-centered design process helped identify new active reading strategies and/or behaviors that emerge when learners engage with multimedia content, elucidate limitations of existing active reading tools, and iteratively revise early SMART Note designs to meet the most pressing needs of learners.

### ***5.2.1 User requirements and target users***

Potential users include all types of learners. However, for the sake of focus, SMART Note has only been developed and tested with college-aged learners in mind. Likewise, although SMART Note features could be applied to many different kinds of educational materials, for the purposes of this dissertation, they have been limited to college-level tablet textbook content.

In general, SMART Note features are envisioned to improve a learner's ability to achieve three main goals during active reading. First, annotation tools should not distract users from learning. For example, allowing users to extract segments of a longer video for future review instead of requiring them to frequently pause, rewind, and/or fast-forward may minimize potentially distracting interaction. Likewise, allowing learners to quickly highlight sentences of expository text with a single tap of the finger could minimize cumbersome interaction patterns typically required by touch screen devices. Second, annotation systems should provide learners a variety of ways to annotate multimedia content and these options should be specifically suited to the tablet experience. These choices should provide a wide array of options that give learners a sense that their active reading patterns are, to some extent, personalized and varied according to their specific needs in an individual active reading session. For example, in addition to adding personalized notes to a video, learners should be able to engage with and annotate video in more specific ways, for example, by extracting specific information from it, such as key term definitions or text-based portions of an accompanying transcript. Third, in addition to allowing learners to access annotations in a list, separate from the body of the book, an improved method should also provide the context and cues necessary to effectively understand the significance of each annotation. For example, icons or labels indicating the media source from which each annotation originated could provide the visual context necessary to help learners better remember key information. Likewise, providing more than one hierarchical view for annotations (beyond a concatenated list) could also prove beneficial.

In light of these three main goals and key requirements outlined in Chapter 4 (p. 54-55), SMART Note focuses on improving two main aspects of the active reading process. First, SMART Note includes support for seven annotation strategies for multimedia content and narrative text. Annotation strategies are designed to minimize mechanical interaction with the device so that learners can focus on active reading learning. Likewise, SMART Note annotation features provide learners with a variety of ways to annotate multimedia content. Second, SMART Note introduces the Concept Map Study Guide, an improved method for concatenating learners' annotations to enhance their ability to effectively study for tests or work-related tasks. The Concept Map Study

Guide differs significantly from annotation notebooks offered by other systems, which typically structure annotations in a long list, organized in the order they were made, with little to no context about their original source. The exploratory research that preceded SMART Note development indicated that this structure might not sufficiently help learners study those annotations later. Specifically, the list structure may make it difficult for learners to remember the source content (i.e., video, audio, text) from which a particular note was taken. Furthermore, the list structure contradicts the very fabric of active reading, which requires that learners be able to make connections among various types of annotations, as well as review and organize notes in personally meaningful ways. The Concept Map Study Guide was designed to improve the review process by allowing learners to filter annotations by type and topic, as well as by providing visual cues to help learners remember from where a particular annotation originated. The sections that follow detail SMART Note annotation features and the Concept Map Study Guide structure.

### **5.2.2 *SMART Note annotation features***

Annotation is a fundamental part of the active reading process. Thus, embodied in the SMART Note design is the key assertion that learners' annotation and study efforts should be equally supported for all of the educational content found in a tablet textbook. Although traditional expository text still comprises the core content of most digital textbooks, multimedia content should not always be considered supplemental. Rather, when audio, video, animations, and other multimedia content are central to learners' full understanding of a concept, equal opportunities for rich engagement with that content should be present. Thus, SMART Note includes seven key annotation features (Table 5.1). Four features apply to video, two features apply to expository text, and one feature applies to photographs and information graphics. The main goals for all features are to minimize mechanical interaction with the device and better support a wide range of active reading strategies specifically for the tablet textbook environment.

Feature	Description
<b>One-tap highlighting</b>	Highlight a full sentence by tapping any part of it.
<b>Video Transcript Annotation</b>	Highlight and/or annotate a dynamic text version of audio that accompanies video.
<b>Video Key Term Capture</b>	Capture key terms and related definitions mentioned in video content with the tap of a button.
<b>Video Segment Capture</b>	Capture and save shorter segments of longer videos for future review with the tap of a button.
<b>Video Point Annotation</b>	Mark and annotate points along a timeline that corresponds with a video.
<b>Key Term Capture</b>	Capture bolded key terms and related definitions in narrative text with the tap of a button.
<b>Image Capture Annotation</b>	Add notes to static images, charts, and diagrams.

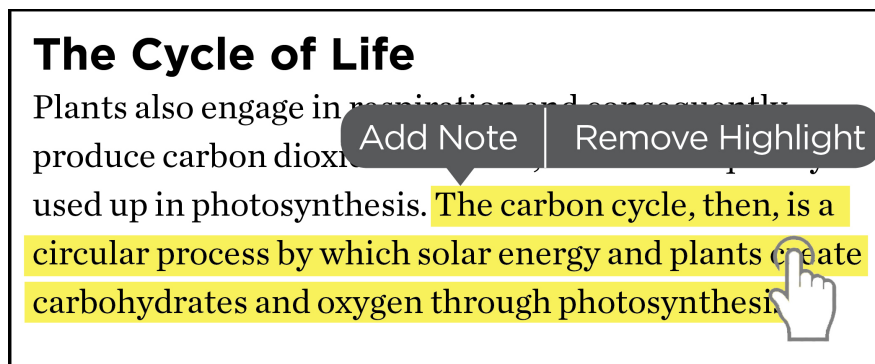
**Table 5.1. SMART Note provides learners with seven key annotation features. Annotations are concatenated in the Concept Map Study Guide, which gives learners cues about the format and significance of each annotation.**

#### *5.2.2.1 Expository text annotation*

SMART Note includes two text-based annotation features, both of which are activated with the tap of a finger to mitigate distractions often caused by the mechanics of interaction.

**One-tap highlighting.** Highlighting words, phrases, and sentences in a textbook is a common learner activity. Thus, all tablet textbook platforms and some other applications allow users to highlight static text and add notes to those highlights. In the tablet textbook, highlighted text is generally saved to a built-in notebook through a “tap-and-swipe highlighting” process. Alternatively, one-tap highlighting in SMART Note allows learners to highlight at the sentence level by tapping any part of a single sentence. Learners can also add a note with the tap of a button. Results from the preliminary study suggest that the “tap-and-swipe” functionality offered by existing systems is a cumbersome interaction pattern and often interrupts the flow of reading. Furthermore, greater potential for mistakes exists due to the small target area and/or when learners aren’t precise enough in dragging the finger over the desired path. If a mistake is made, the learner must tap the portion of text that was incorrectly highlighted and select “remove highlight” or “clear” from a resulting popup menu.

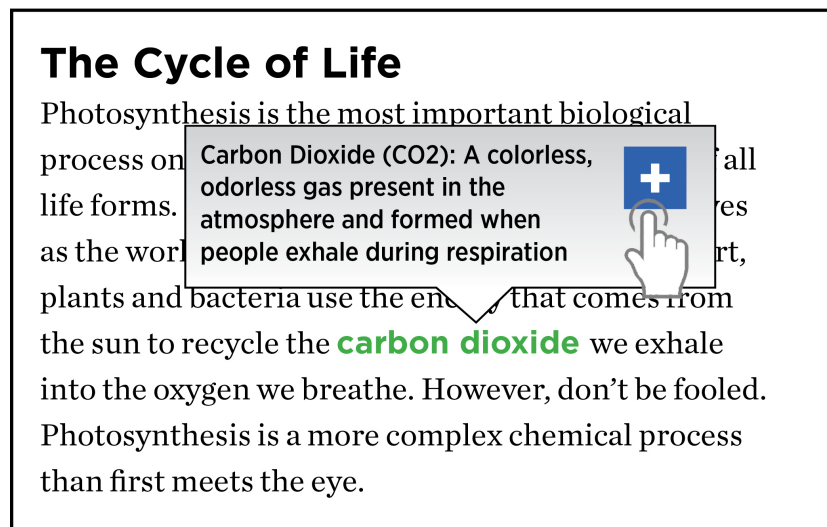
Granted, one-tap highlighting does not provide learners with the ability to select portions of a sentence or single words for highlighting, which could be viewed as a limitation of this tool. However, one-tap highlighting could be advantageous in two ways. First, what the user gives up in terms of precision is gained in terms of efficiency and freedom from distractions that occur during the often-cumbersome tap-and-swipe functionality. Second, highlighted text is generally included in the annotation notebooks. Thus, if a learner only highlights one word or a sentence fragment, important contextual clues are often lost, rendering the highlighted text relatively worthless when the learner uses the notebook to study later. Systems like Inkling and iBooks Author do allow learners to tap a button in the notebook to return to the page on which the highlighted text first appeared. But when they enact this pattern, they are catapulted back into the book, away from the collection of notes they were in the process of studying. This can be both disorienting and cumbersome. Thus, SMART Note's one-tap highlighting mitigates tension that may exist between operating cumbersome system mechanics and learning, which was noted as a challenge in the preliminary study. By allowing users to highlight a single sentence and then continue reading, this feature minimizes distraction and limits the extent to which learners must grapple with the mechanics of the touchscreen interface. Figure 5.1 illustrates the design and interaction pattern for this feature.



**Figure 5.1. SMART Note's one-tap highlighting allows learners to tap any part of the sentence to highlight it.**

**Key term capture.** Key terms are commonly found in printed textbooks, and the trend to call attention to and define important words and phrases has carried over into the digital environment. Most interactive textbooks include bolded key terms that learners

can tap to view a definition. However, for most tablet textbook platforms, such as InKling, Kno, and iBooks Author, there is no way to save individual key terms to the notebook. To address this, SMART Note's key term capture allows learners to save those terms and definitions to the Concept Map Study Guide with the tap of a button. This feature allows learners to activate a key term popup by tapping bolded words found in narrative text blocks. Popups include key term definitions and images when appropriate. Learners may also choose to capture a key term and definition by tapping a "+" button in the popup, or they may ignore it and keep reading. If a key term is captured, the definition is saved separately along with other annotations. Key terms can also be viewed in the context of a complete glossary of terms. Thus, key term capture saves learners time and mechanical interaction with the device, considering that the alternative would be to manually transcribe individual key terms and definitions. Figure 5.2 illustrates the design and interaction pattern for this feature.



**Figure 5.2. SMART Note's key term capture allows learners to view and save key terms and definitions with the simple tap of a button.**

#### 5.2.2.2 Video annotation

Four video annotation features were conceptualized for SMART Note (Figure 5.3) in light of findings from the preliminary study chronicled in Chapter 4. These features were designed with an eye toward mitigating distractions caused by the mechanics of interaction and providing learners with a more robust set of options for



TRANSCRIPT ON

### Photosynthetic Equation

When humans exhale, they release carbon dioxide into the environment. The CO<sub>2</sub> is absorbed by thylakoids in plants and combine with water to produce oxygen and glucose. The plant uses most of the glucose for energy, while most of the oxygen is released into the atmosphere. Plants and animals absorb this oxygen when they breathe, through the process of respiration, and the carbon cycle begins again.

### Carbon Cycle

Carbon dioxide and water are taken in as food for plants. When plants absorb sunlight, the carbon dioxide and water molecules are converted into carbohydrates. Then, glucose particles and oxygen molecules are formed, providing another energy source. The oxygen is released by the plants into the atmosphere, providing humans and animals with the basis for respiration.

B

CARBON CYCLE +

### MY NOTES

The Carbon Cycle

Carbon Dioxide CO<sub>2</sub>

A colorless, odorless gas present in the atmosphere and formed when people exhale during respiration

00:26 | Video: The Photosynthetic Equation

Student added a note here. This is the note the student took to go along with this point in the video. More goes here to fill this space. Student added a note here. This is the note the student took to go along with this point in the video. More goes here to fill this space.

**Figure 5.3. SMART Note offers four video annotation features:**  
**(a) video transcript annotation, (b) video key term capture,**  
**(c) segment capture, and (d) point annotation.**

annotating audiovisual content. Following is a brief overview of the functionality of each video annotation feature, as well as an explanation of how each feature ties to key requirements outlined in the previous chapter.

***Video transcript annotation.*** Important information is often delivered in the audio voiceover that accompanies a video or animation. However, results from the preliminary

study indicate that the transient nature of audiovisual content often makes it difficult for learners to mentally process and retain information quickly. With SMART Note's video transcript annotation, a transcript view can be activated that displays a dynamic text version of audio accompanying a video or animation. Text in the transcript can be highlighted and saved for future review. Furthermore, highlighted text from videos can also be used to navigate back to the point in the video from which the text was taken. Learners can tap text highlighted in the transcript to navigate to the point in the video with which the text corresponds. Thus, transcript annotation provides learners with a concrete reference point that is easy to comprehend as the video is playing and then review later when preparing for exams or class assignments. Figure 5.3a illustrates the design for this feature.

***Video key term capture.*** Like narrative text that includes key terms and definitions, videos and animations often contain key terms defined aurally in the accompanying audio track. SMART Note's video key term capture allows learners to activate a popup view that alerts them when keywords and phrases are mentioned in a video. When key terms are mentioned in a video, they display on the screen for a short period of time. Then, the key term and its definition are automatically saved to the Concept Map Study Guide when the "+" button next to the word(s) is tapped. Key terms stay visible for a few seconds and then disappear as the video plays. Key terms can also be viewed in the context of a complete glossary of terms. Like video transcript annotation, the video key term capture feature combats the transient nature of audio by providing learners with the opportunity to save key terms and definitions easily and efficiently. Figure 5.3b illustrates the design for this feature.

***Video segment capture.*** Videos often contain important information for learners to annotate and review. However, most existing tablet textbook systems only allow learners to bookmark and add notes to a whole video. Alternatively, SMART Note's video segment capture allows learners to save shorter segments of longer videos for future review with the tap of a button. A segment is defined as a portion of a longer video that is identified when the book designed. In other words, tablet textbook authors and developers should provide a number of logical segments within a larger video that could be partitioned and watched separately from the larger video. As the video plays, the bar

below it indicates the learner's progress through predetermined segments in the video, as well as progress through the current segment. When the user taps the "capture segment" button, the currently playing segment is saved in the Concept Map Study Guide, along with other annotations, for future review. Later, learners can easily access and review isolated segments with the tap of a button. It is important to note that segment capture does not require videos to be developed differently. It merely requires that authors and/or developers identify key points within an existing video where logical pauses, shifts in topic, and/or new images occur. Results from the preliminary study indicate that annotating a single point along a video timeline often doesn't provide users with enough context for an individual note. Likewise, several learners were observed attempting to sketch a series of video frames in an effort to capture important information contained in a single sequence. Thus, video segment capture, allows learners to be more precise and efficient with their video annotations by allowing them to isolate clips from a longer video. Likewise, because the segments are predetermined by the textbook author/producer, learners do not have to grapple with the mechanics of the video interface, such as pausing to set the starting and ending points of a desired segment. Rather, they can simply tap one button to extract a desired segment and save it to the Concept Map Study Guide for future review. Figure 5.3c illustrates the design for this feature.

***Video point annotation.*** A learner may also wish to add personalized notes to a video that are tied to a certain point in the video's timeline. SMART Note's video point annotation makes this possible. At any point while a video is playing, learners may tap the green point annotation button to pause the video while they type notes. That annotation is then connected to the point at which the video was paused so that learners can return to that part of the video later by tapping the annotation that appears in the Concept Map Study Guide. Video point annotation has been implemented in a few well-established educational video platforms, including Apple's iTunes U and YouTube. It is worth noting, however, that several of the most common tablet textbook platforms, including Inkling, Kno, and iBooks Author, do not currently provide this functionality. Results from the preliminary study suggest that only allowing annotation to be attached to a whole video does not provide enough flexibility or precision regarding video note

taking. Additionally, existing systems force the learner to engage in cumbersome interaction mechanics, such as pausing, rewinding, etc., if they wish to re-watch a portion of video associated with a particular note. Video point annotation addresses these concerns by allowing learners to attach and later access personalized notes to specific points in a video timeline with the tap of a button. Figure 5.3d illustrates the design for this feature.

### 5.2.2.3 Image annotation

**Image capture and annotation.** Like videos and text, static images also contain valuable information for students to annotate and study. SMART Note’s image capture and annotation feature allows learners to add notes to static images or individual frames of interactive graphics, charts, and diagrams. To do so, a learner taps the “+” button associated with an image, which activates the touch screen keyboard for note taking. The personalized annotations, as well as a thumbnail of the image are automatically saved to the Concept Map Study Guide. Similar functionality has been implemented in a few well-established digital textbook platforms, including iBooks Author and Inkling. Figure 5.4 illustrates the design and interaction pattern for this feature.



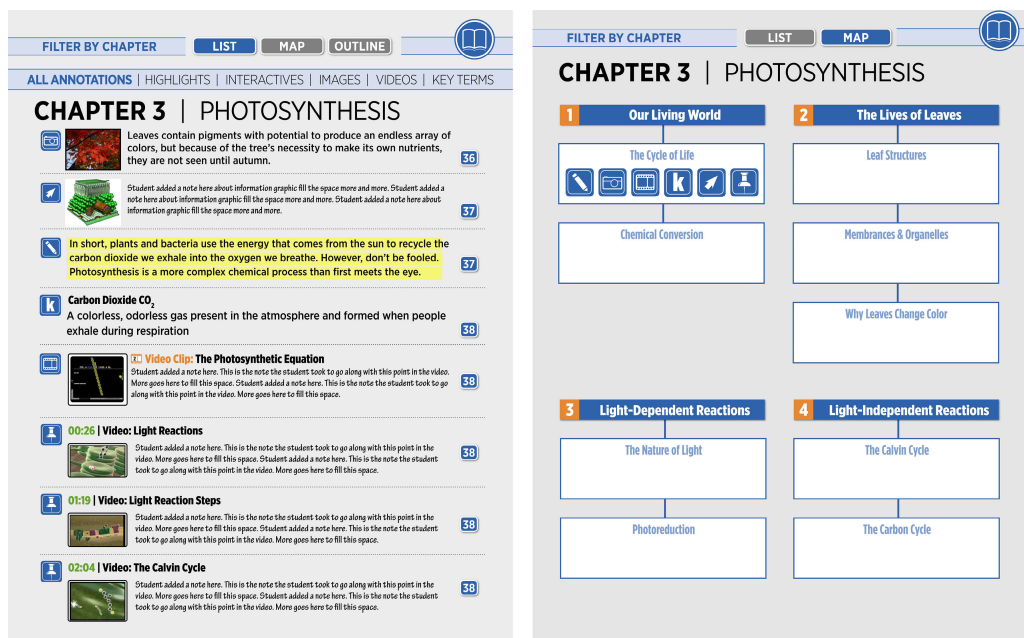
**Figure 5.4.** SMART Note’s image capture allows learners to save a static image to the Concept Map Study Guide and add notes to it.

### 5.2.3 *Concept map study guide*

After a learner has completed an initial reading and annotation session, it is common to revisit annotations (i.e., handwritten or typed notes, flash cards, outlines, etc.) to memorize/learn important information. The digital environment provides a number of novel affordances where this activity is concerned, especially when it comes to concatenating annotations into a separate list. However, because content is delivered in multiple media formats in the tablet environment, it becomes necessary to consider how the notebook structure can be improved to better support learners' ability to make sense of and mentally map annotations to their sources.

To address this, SMART Note also includes the Concept Map Study Guide, which is a visually organized, interactive concatenation of all of the annotations a learner makes over a particular unit of content (i.e., textbook chapter). The Concept Map Study Guide makes two main contributions to the review experience. First, it allows learners to choose from two different views, *visual list view* or *map view*, as well as filter their annotations by the type of media format from which they came. Alternative views and filtering capabilities provide different, conceptually significant formats in which to organize annotations, allowing learners to make more personalized choices about how they review a chapter or section of a tablet textbook. Second, the Concept Map Study Guide implements simple visual iconography to help learners more easily make connections between individual notes and the content types from which they came. Thus, the Concept Map Study Guide serves as a visual outline of the most salient portions of a textbook, as well as a logical organization of learners' notes and annotations. By mapping learners' notes through a visualization of the complete outline of a book unit or chapter, learners may be able to better remember and make connections among important information.

The Concept Map Study Guide is designed to be more interactive than similar outlines offered by existing systems, such as iBooks Author and Inkling. Results from the preliminary study indicate that learners need help integrating concepts in multimedia with notes from other sources, as well as struggle to make connections among notes, pages, etc. Furthermore, those results indicated that systems that provide learners with a long list of notes to study fall short of providing them with the context and cues necessary to effectively understand the significance of each annotation. Likewise, it is often difficult



**Figure 5.5. SMART Note’s visual list view (a) includes color-coding and icons that serve as visual references for each annotation and allows learners to filter annotations by type based on the media format from which they were derived. Map view (b) presents annotations in the form of an interactive schematic with color-coded icons to indicate media type.**

to remember the media source from which each note originally came. Thus, the Concept Map Study Guide is intended to help learners more easily make sense of and remember information by providing a more concrete representation of their notes, as well as allow learners to assess the quality and completeness of their notes by alerting them when they have not developed annotations for important concepts.

**Annotation visual list view.** Although list view is common in most existing tablet textbook systems, the Concept Map Study Guide visual list view makes several improvements. In addition to allowing learners to view all of their annotations in the order they were made, Concept Map Study Guide visual list view also allows learners filter annotations by type based on the media format from which they were derived. Thus, a learner who only wants to study video annotations can do so by filtering annotations accordingly. Also, color-coded labels and/or icons provide clues about the notes. For example, the video segment capture button is orange with a video clip icon on it. Corresponding annotations are marked with the same icon and labels make use of the same color scheme to provide easy-to-understand visual cues. Likewise, buttons can be

used to link the learner back to the original source. Figure 5.5a illustrates SMART Note's visual list view.

***Annotation map view.*** In map view, learners first see a complete interactive schematic with sections and headings that correspond with the main sub-sections of a chapter. The schematic allows learners to see a complete framework for the unit they studied with their own annotations included in each sub-section. Additionally, icons are used to further group annotations by type (i.e., video, audio, text, etc.), allowing learners to quickly form a mental map of the topics covered in the chapter and the media format in which information was delivered. Map view then serves as an interactive tool that learners can use to browse annotations. Learners can tap a node on the map to view the annotations that relate to it. And if no notes were taken in relation to a node on the map, learners are alerted so that they can either return to the sections of the text or move on. Figure 5.5b illustrates map view. Ultimately, SMART Note annotation tools and the Concept Map Study Guide are intended to work together and create a more robust and memorable active reading experience.

#### ***5.2.4 Usage scenario***

A usage scenario is given here to illustrate how SMART Note works. Jill is an undergraduate student at a four-year university. Jill has always been a relatively good student, and she believes it is important to receive high marks in all of her classes. She is a freshman, and her class schedule is mostly comprised general studies courses like Psychology 100, History 101, and an introductory Biology course. Jill owns an iPad that she purchased both for personal use and for use in school. Her Biology 100 professor has opted to require an interactive, multimedia textbook this semester, and Jill purchased the tablet version so that she could consume the book on her iPad.

In the first week of class, Jill's professor requires that students read and study the chapter on photosynthesis, which includes expository text, video animations, interactive graphics, and image galleries. Students are informed that they will be tested over the material at the end of the week. Jill has little prior experience with this topic, so she intends to thoroughly study the chapter, carefully taking notes as she reads and then closely reviewing the material and her notes before taking the test. Jill opens the

photosynthesis chapter on her iPad and begins reading. On the first page, she encounters a bold word—*thylakoid*—that she has never seen before. She taps it to reveal a definition, reads the definition, and then taps the “+” button in the popup window to save the key term to her Concept Map Study Guide so that she can review it later. As she reads, Jill repeats this process every time she encounters a key term with which she is unfamiliar. Jill also uses the one-tap highlighting feature frequently as she encounters important information that she wants to return to and study later. Occasionally, she also uses the “add note” feature to put concepts in her own words or remind herself of why a particular piece of content is important.

On the third page of the chapter, Jill encounters a six-minute video animation that visualizes the process of photosynthesis, providing great detail over what occurs in the atmosphere and inside a plant during the photosynthetic process. At first, the transcript for the video is also visible. However, Jill wants to watch the video in a larger presentation, so she taps the on/off toggle switch to increase the size of the video and make the transcript invisible. As she watches the video, key terms popup on the screen as they are mentioned in the video. As she watches the video, she taps the “+” button next to key terms with which she is unfamiliar to add them to her Concept Map Study Guide for future review. As the video plays, she also sees that it is divided into five shorter segments, each labeled according to the main concept that is being illustrated. The first segment explains the general process by which plants and other organisms convert light to energy. She remembers this basic explanation from a high school lesson, so she just keeps watching. However, the second segment explains in greater detail what happens to a plant’s cells as it engages in chemical conversion. Jill is instantly struck by how much more detailed this animation is than anything she has previously encountered, so she taps the orange *segment capture* button to save that portion of the video to her study guide for future review. Later, she decides to add a personalized note to a point in a video that discusses the Calvin Cycle, so she taps the green *point annotation* button and types a few brief sentences that puts the concept into her own words. The video pauses as she types. When she taps the *done* button, the video continues to play, and her annotation is added to her study guide along with a time stamp and frame grab from that point in the video. She adds a few more personalized notes to other points in the video as well. After she is



finished watching and annotating the video, Jill turns the transcript back on and skims it looking for important information to highlight. She sees a few sentences of importance and highlights them. When she does, the highlighted text, along with a frame grab from that point in the video, are added to her study guide. After finishing with the video, Jill moves on to the next page and continues to read. When Jill is finished reading and annotating the photosynthesis chapter, she taps the Concept Map Study Guide button in the upper-right corner of the last page of the chapter to review her notes. First, she skims through her annotations, filtering them by type (i.e., highlights, interactives, images, videos, and key terms) to get a sense of how many annotations she has in each category. Within each category, she taps each annotation to review it. She also re-watches several video segments and reads over all of the key terms and definitions she collected. At this point, Jill stops and takes a break from her reading and studying.

The following day, Jill returns to the chapter, and this time, she taps the *map view* button in the study guide. Here, she is able to see a complete outline of the chapter in the form of a flow chart with the different sub-sections of the chapter labeling each “node” of the flow chart. Also in each node, she sees icons that represent each type of media (i.e., text, interactives, images, videos, and key terms) that she took notes over for each section. She taps on each individual node to reveal her annotations and reviews them one at a time. A few of the nodes are empty, indicating she didn’t take notes over those sections. For most, she is confident she understands the material and is not worried by the empty nodes. However, she is concerned that she doesn’t completely remember the information in one node, titled “The Nature of Light.” So she taps on the empty node to return to that part of the chapter, review the section, and add a few notes. Jill repeats these steps until she is confident she is ready for the upcoming quiz.

### **5.2.5 *System architecture and platforms***

For research, the SMART Note prototype was developed as a web app using HTML5 and CSS for the Retina iPad device. The prototype uses JavaScript for touch and gesture support to mimic native app functionality and AJAX with Handlebars for client-side templating. Visuals are styled with SASS, a CSS preprocessor, to save time on boilerplate code and to allow for an iterative development cycle. Ultimately, SMART

Note is envisioned as a set of tools that could be integrated with any tablet textbook platform and used on any standards-compliant, web-capable tablet, including Android, iOS, and Windows devices, as well as on desktop and laptop computers. The SMART Note web app can be accessed at <http://smartnoteproject.com/smart/> on any device or computer. However, for optimum functionality, view it on any Retina iPad device.

### **5.3 Iterative design and usability evaluations**

SMART Note was prototyped and iteratively tested in two cycles with 10 users each. In each session, a task-based inspection explored usability and user experience with SMART Note at two levels of fidelity. Low-fidelity wireframe prototypes with dummy content and only basic interactivity were designed for the first round of testing. After modifications were made to prototypes based on user feedback, medium-fidelity prototypes with enhanced graphic design and interactivity were designed for the second round of testing. The first two rounds of prototypes were developed using the Adobe Digital Publishing Suite, which allows for rapid design and prototyping of interactive tablet apps. Based on feedback from the first two rounds of testing, a single fully functional web app was designed using HTML5 and CSS.

In each of the first two rounds of inspection, two different prototypes were tested in order to compare usability and user experience with alternative interaction patterns, information architectures, and overall design aesthetics. Both sets of inspections targeted specific active reading strategies through task-based usability research based on rigidly defined tasks that exposed participants to all key features in the SMART Note system. Following is a detailed explanation of procedures and results for the first two rounds of usability testing. This experiment has been approved by IRB #IRB-557346-1.

#### ***5.3.1 Usability round one: Low-fidelity prototypes***

In Round One, low-fidelity wireframe prototypes focused on basic information architecture (e.g., layout, navigation structure and labeling, and general functionality of features) and did not include real multimedia content. Wireframes included narrative text and real section labels for a unit on color theory. Black boxes were used as placeholders for visual and/or multimedia content.

#### *5.3.1.1 Participants, procedure, and stimuli*

Ten undergraduate or graduate students (aged 18-26; five male, five female) at Ball State University were recruited to participate via an all-campus email. The only inclusion criterion was that participants own or have extensive experience with a tablet device, such as an iPad or Android tablet.

Participants first completed informed consent and brief demographic and reading habits questionnaires. Then, each participant engaged in a 16-task session (Table 5.2 on the next page) with each of two versions of SMART Note prototypes. Participants were not given any training about the interface prior to the usability inspection. The nature of tasks was twofold: 1) Seven articulation tasks required participants to explore parts of the prototype and explain how they believed each would function. Articulation tasks were intended to gauge how intuitive the interface was by exploring the extent to which participants could accurately explain how the interface would work without actually interacting with it. 2) Nine interaction tasks required participants to complete specific annotation strategies, exposing them to all of the key features in the SMART Note design. Interaction tasks were intended to explore how easy the designs were to learn and use by examining whether participants were able to accurately complete each task.

The order in which alternative designs was presented was counterbalanced across participants to minimize learning effect. During task-based inspections, participants rated the perceived difficulty of each task and the researcher completed a success rating for each task. Participants also completed the Systems Usability Scale (SUS) (Brooke, 1996) for each prototype. Follow-up questions about usability and preferences regarding the prototypes rounded out the research.

In Round One, participants were exposed to two different SMART Note prototypes. Each was designed with content from a chapter on color theory (the same content used in the behavioral study reported in Chapter 4). The prototype contained the body of the chapter, with three pages of narrative text, and the digital notebook, which included six pages of annotations in visual list view and a concept map study guide that organized notes by key headings and subheadings from the chapter.

Task # Type	Task Instructions
1 A-1	Explore the first page of the SMART Note interface. As you do, please explain how you would study the material on it.
2 A-2	Explore the second page of the SMART Note interface. As you do, please explain how you would study the material on it.
3 A-3	Explore the third page of the SMART Note interface. As you do, please explain how you would study the material on it.
4 I-1	Return to the first page of the chapter. Try to make some notes over the image you see there.
5 I-2	Imagine you want to save a key term so you can review it later. Try to do that.
6 I-3	Now turn to the second page of the chapter. Make some notes over the interactive graphic you see there.
7 I-4	Notice some of the text has been highlighted. Imagine this is an annotation you made previously. Add notes to the highlighted text.
8 I-5	Now, turn to the third page of the chapter. Save key terms mentioned in the video.
9 A-4	Notice there is a transcript that accompanies the video. What would you expect to be able to do with this transcript?
10 I-6	Imagine you have completed reading the chapter and want to look at the annotations you made while you were reading. Try to do that.
11 A-5	Examine the first page of your notes and explain how you think this tool works. Also, explain what you think each of the icons means.
12 I-7	Now, imagine you want to review the video clip on digital color reproduction. Try to do that.
13 I-8	Now, imagine you would like to add more notes to the video clip on digital color reproduction. Try to do that.
14 A-6	Notice that you can change the way your annotations are organized. Please do that, and explain what happens when you do. Specifically, explain how you think this new view works.
15 A-7	Explain how you think each of the annotation views differs from one another.
16 I-9	Now you want to return to the body of the chapter. Try to do that.

**Table 5.2. Each participant engaged in a 16-task session with each of two versions of SMART Note prototypes. Seven articulation tasks (A) required participants to explain how they perceived parts of the interface would work. Nine interaction tasks (I) required participants to complete a number of specific annotation strategies.**

There were two main differences between the prototypes, the first semiotic and the second structural. The *Combination Prototype* included both icons and word-based labels for buttons used to operate key annotation and study guide features (Figure 5.6), while the *Icon Prototype* included only icons for those controls (Figure 5.7).

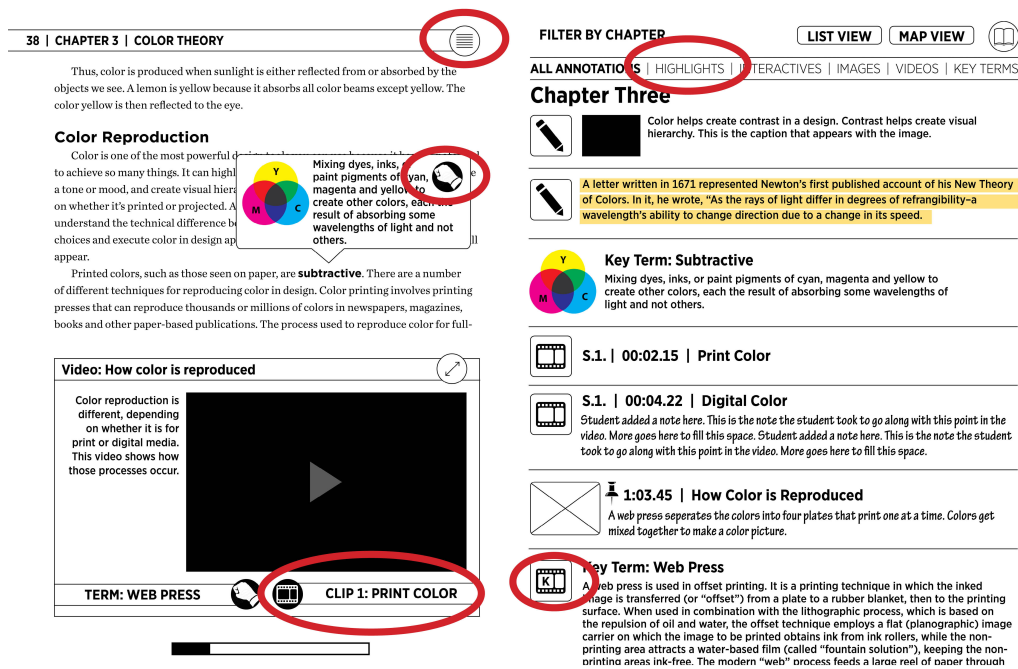


Figure 5.6. The *Combination Prototype* included both icons and word-based labels for buttons used to operate key annotation and study guide features.

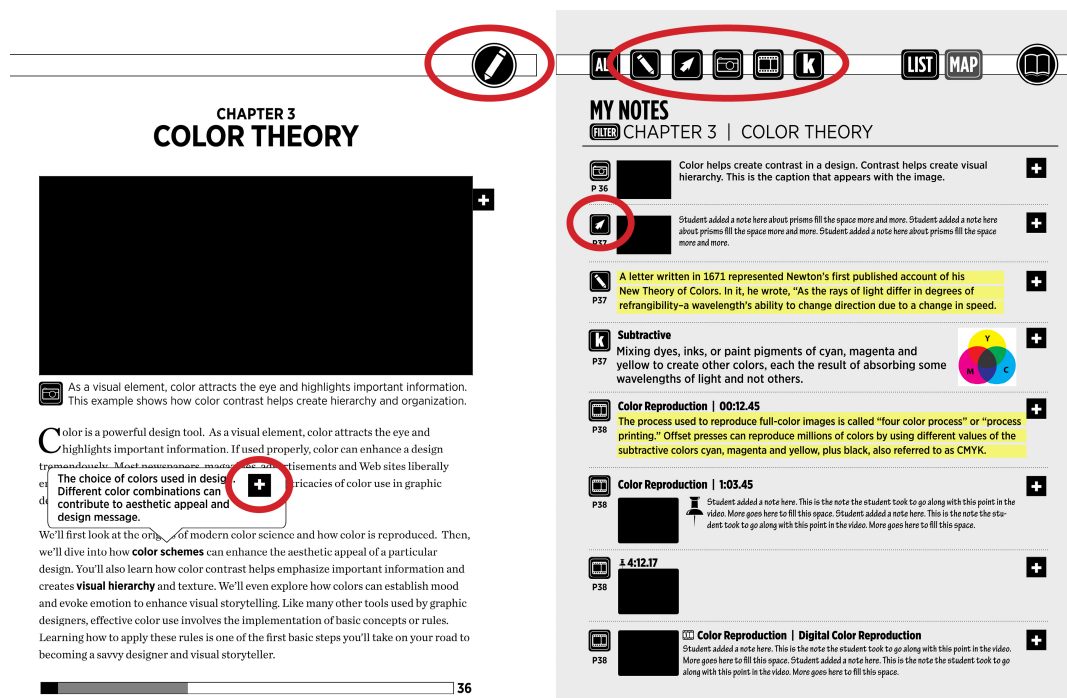


Figure 5.7. The *Icon Prototype* included only icons for buttons used to operate key annotation and study guide features.

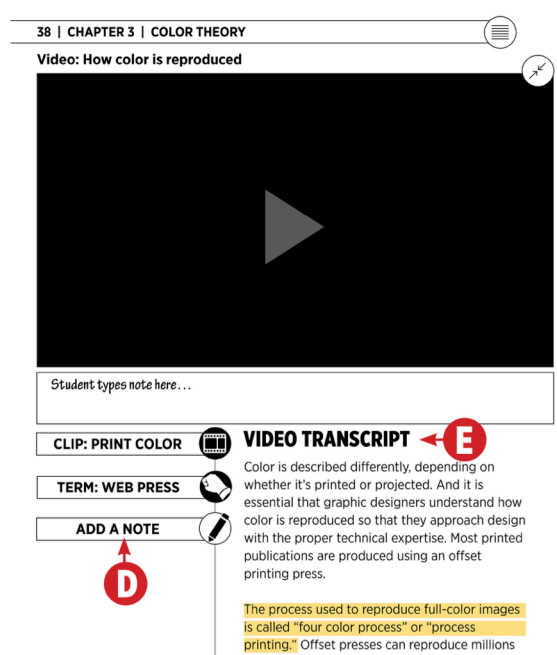
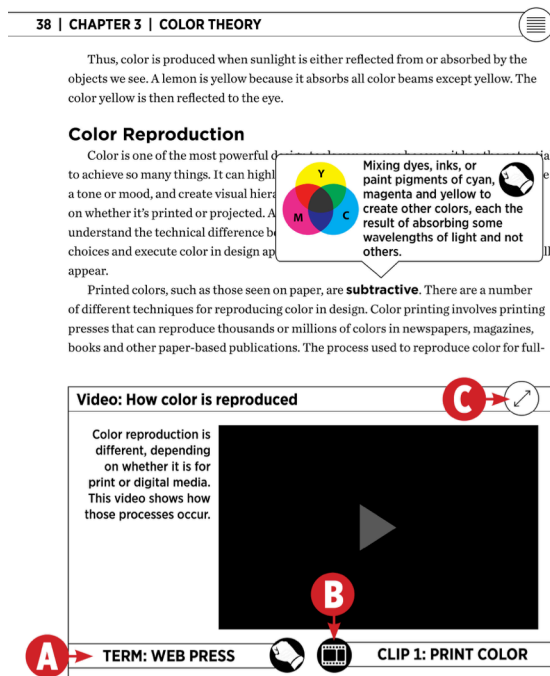


Figure 5.8. The *Combination Prototype* allowed users to watch a small version of videos integrated into the design of the page and capture key terms (A) and video segments (B) as they watched. However, they could also tap a button (C) to expand the video full screen where they could also add personalized notes (D) and view the video transcript (E).

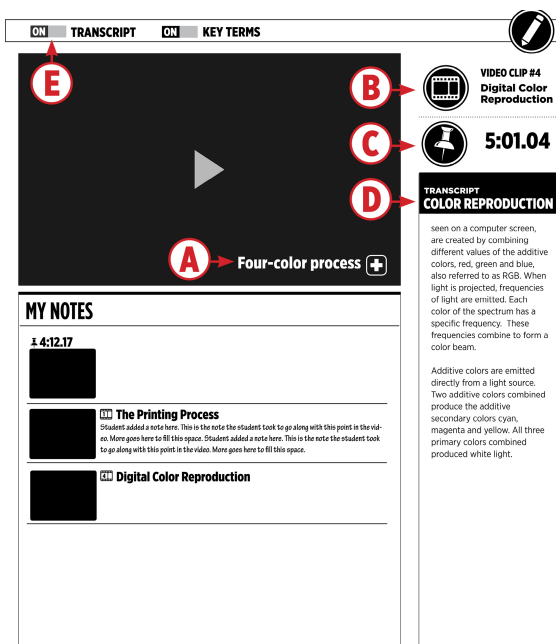
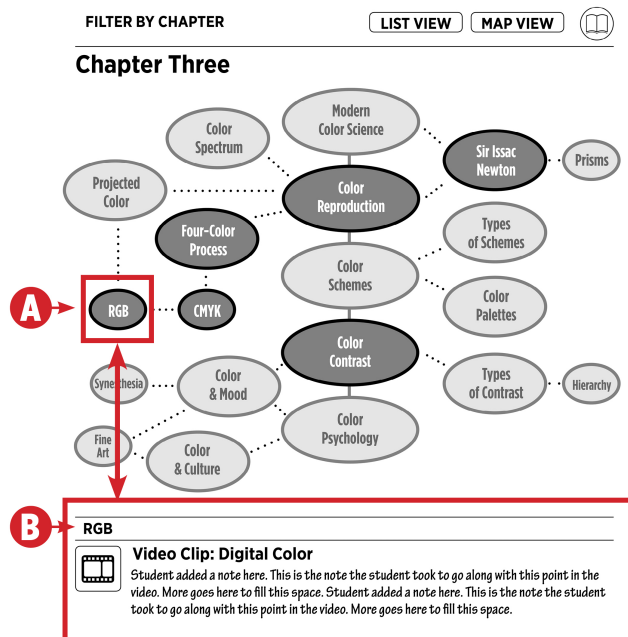
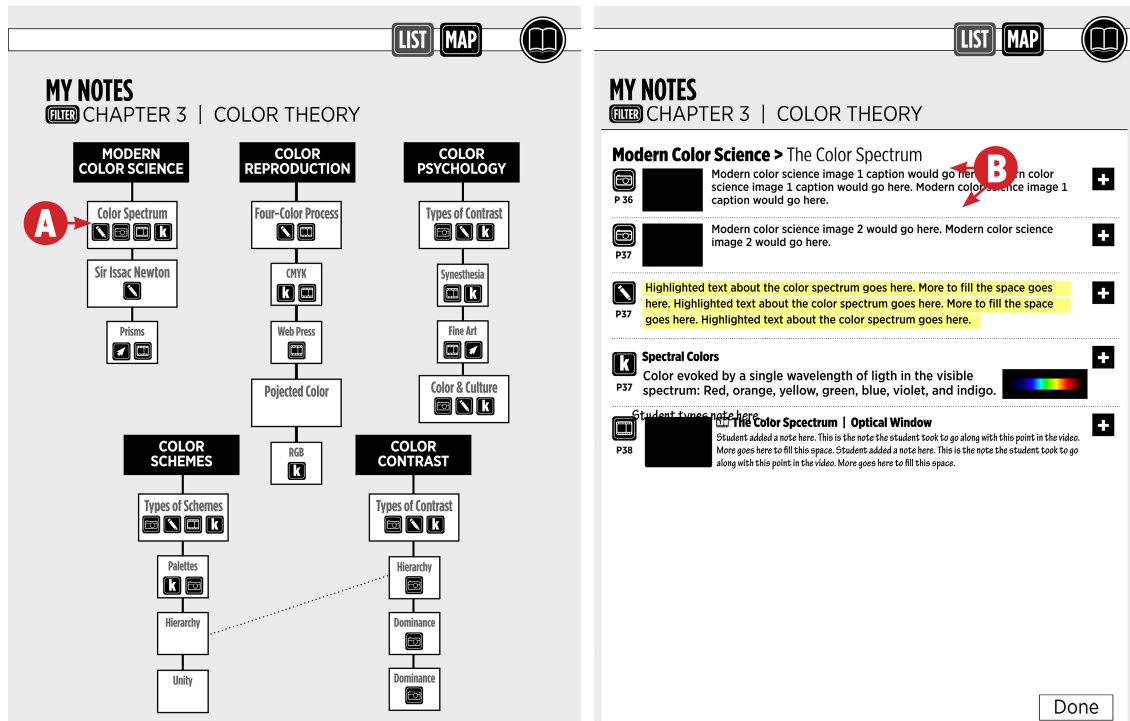


Figure 5.9. The *Icon Prototype* presented videos and all corresponding annotation features—i.e., key term capture (A), segment capture (B), point (C) and transcript annotation (D)—on a single page. Users could then turn off the transcript (E) to see the video larger but keep all other annotation features.

Additionally, two main structural differences existed between the prototypes. First, the *Combination Prototype* integrated video boxes with narrative text on the same page and provided key term capture and video segment capture there as well. Then, participants could also tap a button to expand the video to full screen where they could also add personalized notes and view the video transcript. This interaction pattern is illustrated in Figure 5.8. The *Icon Prototype*, on the other hand, presented videos and all corresponding annotation features—i.e., key term capture, segment capture, point and transcript annotation—on a single page. Users could then turn off the transcript to see the video larger but keep all other annotation features. This interaction pattern is illustrated in Figure 5.9. Second, the *Combination Prototype* Concept Map Study Guide structure (Figure 5.10) was a web-like diagram in which nodes represented main topics and key terms in the chapter with lines connecting related concepts. Nodes were also color coded to indicate which topics the learner had annotated. The *Icon Prototype* Concept Map Study Guide structure (Figure 5.11) presented main chapter headings in the form of a hierarchical flow chart. In each node, icons were used to indicate which sections the learner had annotated and to provide the learner with visual cues about what kinds of media had been annotated.



**Figure 5.10. The *Combination Prototype* Concept Map Study Guide was designed as a web-like diagram in which nodes represented main topics and key terms in the chapter with lines connecting related concepts. Nodes were also color coded to indicate which topics the learner had annotated. When the learner tapped a node (A), the corresponding notes for that topic appeared below the map (B).**



**Figure 5.11. The *Icon Prototype* Concept Map Study Guide offered chapter headings in the form of a hierarchical flow chart. In each node, icons (A) were used to indicate which sections the learner had annotated and provide visual cues about what kinds of media had been annotated. When the learner tapped a node, the corresponding annotations for that topic appeared below the map (B).**

### 5.3.1.2 Results

Overall response to both Round One SMART Note prototypes was positive. All seven of the SMART Note annotation features explored in the first round of usability inspection received favorable usefulness ratings from users (Figure 5.12). On average, participants found SMART Note designs easy to learn (*Combination* SUS: 4.9; *Icon* SUS = 4.0) and easy to use (*Combination* SUS: 4.1; *Icon* SUS = 3.8). Most participants also reported they would use SMART Note frequently if it were available (*Combination* SUS: 4.3; *Icon* SUS = 4.3). The *Combination* prototype scored the same, or slightly better, on all SUS items. Regarding learnability of the *Combination* prototype, a few participants added comments to their SUS forms such as, “The system was pretty easy to navigate through. It would only take a little bit of time to understand the function of the buttons and available tools,” [P3]. Likewise, similar comments were made regarding learnability, such as, “When I saw how each icon/button was used and learned the purpose of them, I



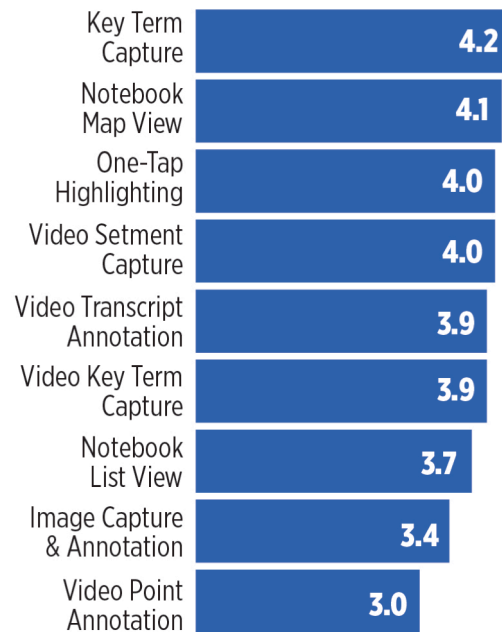
was able to grasp the hang of everything,” [P1]. Although the *Icon* prototype also received favorable feedback, one user noted that it might be a bit more difficult to learn than the other: “It seemed harder to navigate. I would need some kind of training or guide to help understand,” [P3]. Figure 5.13 displays average responses to the SUS for each of the Round One prototypes.

In general, for both the *Combination Prototype* and the *Icon Prototype* wireframes, only a few tasks yielded success rates below 70%. The most significant challenges centered on participants’ ability to easily and accurately understand the meaning of

some of the icons used for a few SMART Note annotation features. Consequently, this also made it difficult in some cases for participants to fully understand the meaning and function of certain features. Figure 5.14 shows the success ratings for each task in the first round of testing for both the combination and icon wireframes.

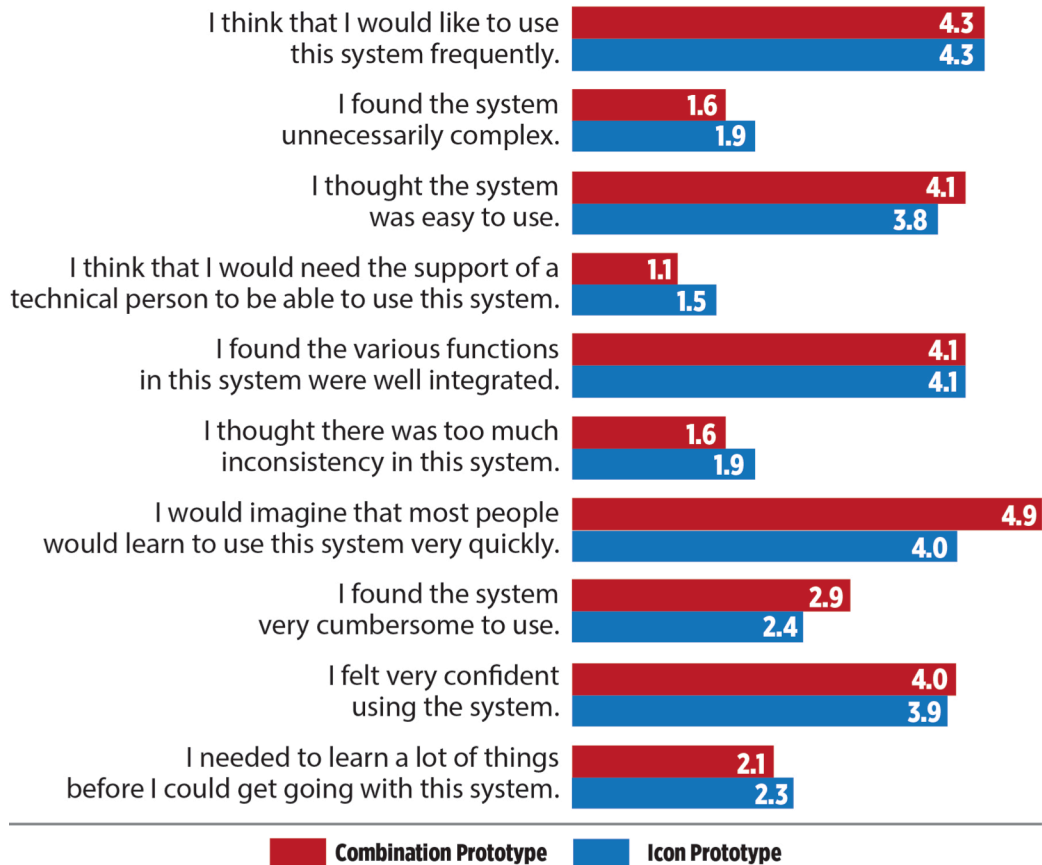
**Low-fidelity combination wireframe.** Three articulation tasks proved problematic, all of which related to users’ inability to understand the meaning of interaction icons. First, participants struggled to understand what would happen if they tapped the icon used to navigate to the Concept Map Study Guide (50% success rate, Task 1; 60% success rate, Task 10). In this version, most mistook it for a menu button. Second, the key term capture icon equally confused participants (50% success rate, Task 5), many of whom noted that the grabbing hand looked more like a punching fist. Third, users had the most trouble making sense of the video segment capture button (40%

#### SMART Note usefulness ratings

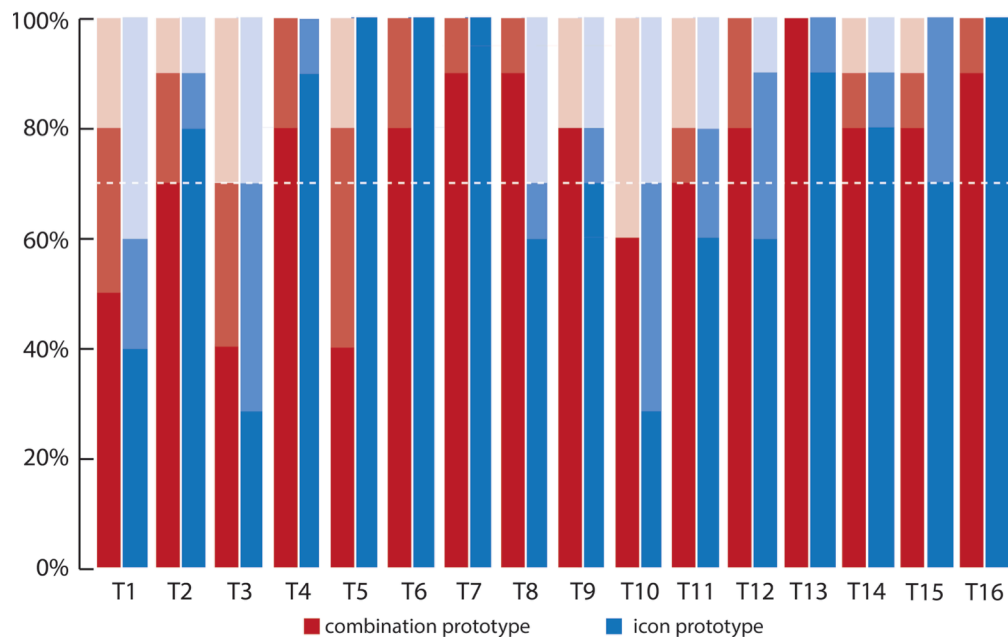


**Figure 5.12. Participants rated how useful they perceived each of the SMART Note annotation features to be on a five-point Likert Scale (five, very useful; one, very un-useful).**

### Average System Usability Ratings - Round One



**Figure 5.13. Average responses to the Systems Usability Scale (SUS) for each of the Round One prototypes**

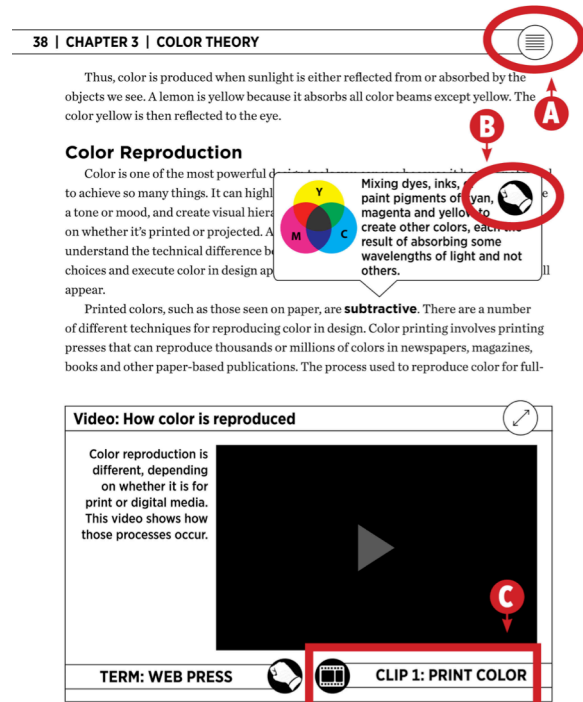


**Figure 5.14. Success rates for combination and icon prototypes in the first round of testing**

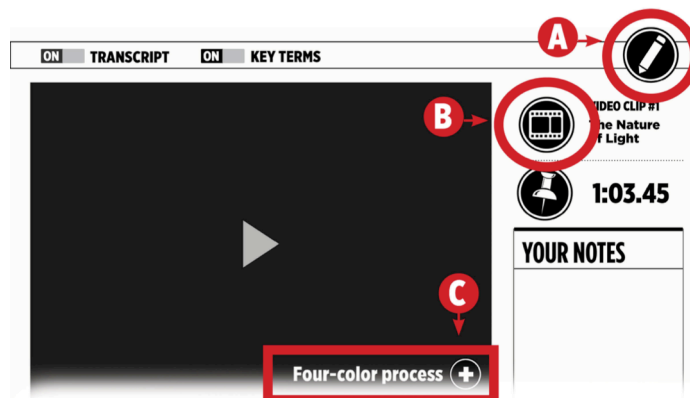
success rate, Task 3). In most cases, users weren't even able to make a guess at what the button meant or would do. Figure 5.15 illustrates problematic icons.

### *Low-fidelity icon wireframe.*

Three articulation tasks were challenging. First, the Concept Map Study Guide navigation button (a pencil) was again confusing (40% success rate, Task 1; 30% success rate, Task 10), as most users reported they thought it was for note taking. Second, the video segment capture feature was also confusing in this prototype (30% success rate, Task 3), as most users did not realize that it was a button, and some indicated they thought it would pull up a new video if tapped. Third, although users more easily understood the meaning of the key term capture button (a “+” sign) in this version, when applied to the video key term capture features, it was more difficult for



**Figure 5.15. Three combination buttons were problematic: (A) Concept Map Study Guide navigation button, (B) key term capture button, and (C) video segment capture button.**



**Figure 5.16. Three icon buttons were problematic: (A) Concept Map Study Guide navigation button, (B) video key term capture button, and (C) video segment capture button.**

users to correctly identify (30% success rate, Task 8). If they noticed it at all, most users thought the “+” sign and key term placed on top of the video was a label for the video as opposed to a key term mentioned in the audio that accompanies the video. Figure 5.16 illustrates problem issues.

#### *5.3.1.3 Discussion*

In spite of a few specific problem areas, failure rates for both the combination prototype and icon prototype were relatively low. Thus, it was only necessary to make a few minor design changes prior to the second round of testing. Specific changes centered on making problematic icons easier to understand, as well as adding additional visual cues to better indicate a feature's meaning and function. During post-task interviews, the general response to SMART Note annotation and study guide features were positive. However, all 10 participants confirmed that some of the icons were confusing. However, more than half ( $n=7$ ) noted that with a little bit of training and/or practice, the SMART Note system would be easy to learn. One participant said, "It would be nice to have a little 'help' button or maybe a screen that explains how to use this system at the beginning. But I think that it wouldn't take long for me to figure it out." [P6].

#### **5.3.2 Usability round two: Medium-fidelity prototypes**

Prior to Round Two of testing, revisions were made to each set of prototypes to address problems, and the level of fidelity was improved. Multimedia content (i.e., audio, video, images, and interactive graphics) was also added to the medium-fidelity prototypes tested in Round Two. Graphic design and refinements in navigation structure, labeling, and functionality were also implemented.

##### *5.3.2.1 Participants, procedure, and stimuli*

Ten new undergraduate or graduate students (aged 18-26; five male, five female) from the same university were recruited for the second round of testing. Again, the only inclusion criterion was that participants own or have extensive experience with a tablet device, such as an iPad or Android tablet. The same procedures from Round One of usability testing were followed in Round Two.

In Round Two, participants were again exposed to two different SMART Note prototypes designed with content from the same chapter on color theory that was used in Round One. The prototype again contained the body of the chapter, with three pages of narrative text, and the digital notebook, which included six pages of annotations in visual list view and map view that organized notes by key headings and subheadings from the



**Figure 5.17. Three main changes were made to the video screens for each prototype to make certain features easier to understand.**

chapter. The module also included one interactive graphic explaining how a prism works and one two-minute video explaining the process of color reproduction. The Concept Map Study Guide was populated with real annotations, which included three video segments, 18 highlighted sentences (four with additional notes added), three annotated interactive graphics, four image annotations, four annotated key terms, and four video point annotations. The aesthetic approach was also improved, with color and other refinements added.

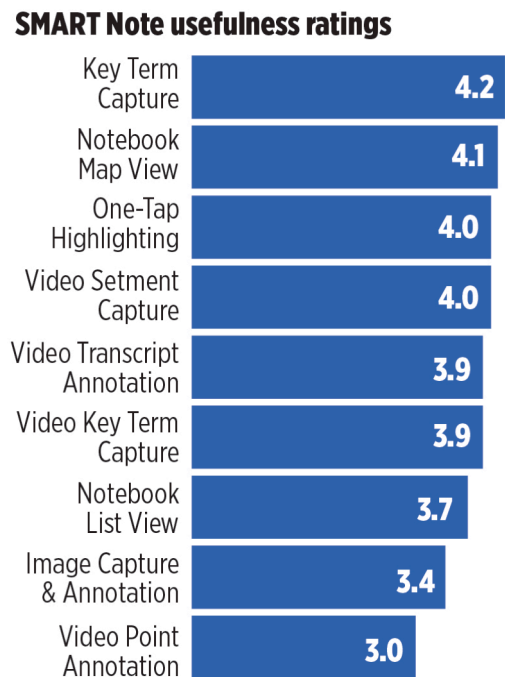
Three main changes were made to the *Combination Prototype* video screen to make certain features easier to understand. First the Concept Map Study Guide button was changed to a label that read “My Notes” (Figure 5.17a). Second, the segment bar was labeled with the name of the corresponding video segment and the button associated with each segment highlighted as the video played (Figure 5.17b). Third, the key term capture button was changed to “+” and combined with animation that allowed key terms to fade in and out when they were mentioned in video (Figure 5.17c). Pop up key terms in narrative text were also modified to include a button that read “Save Term” in place of the grabbing hand icon. Additionally, three main changes were also made to the *Icon Prototype* video screen to make certain features easier to understand. First, the Concept

Map Study Guide button was changed to look like an actual notebook (Figure 5.17d). Second, the video segment capture design was redesigned to include a color-coded and segmented progress bar below the video. As the video played, the segment currently playing highlighted (Figure 5.17e). Third, video key terms were changed to look less like labels and more like independent elements. Animation was also added that allowed the key terms to fade in and out when they were mentioned in video (Figure 5.17f).

### 5.3.2.2 Results

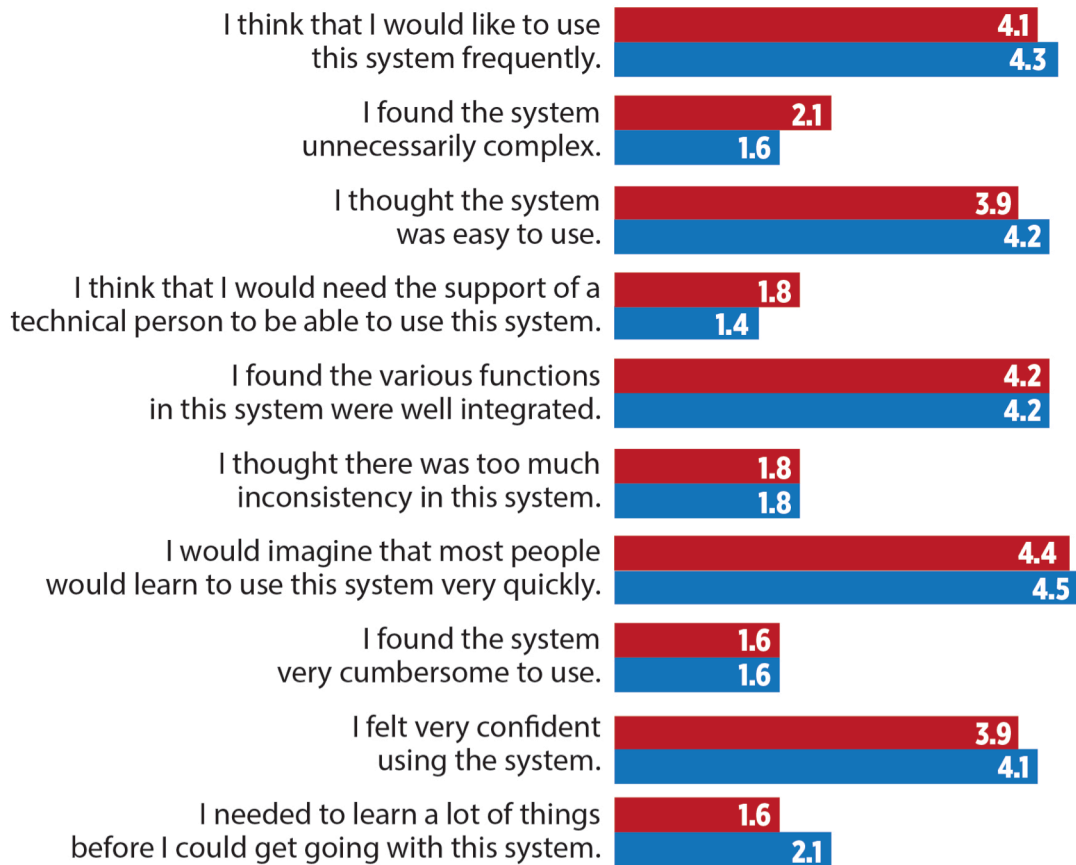
Overall response to both Round Two SMART Note prototypes was again positive, with usefulness ratings increasing slightly from Round One (Figure 5.18). Moreover, participants again found SMART Note designs easy to learn (*Combination* SUS: 4.4; *Icon* SUS = 4.5) and easy to use (*Combination* SUS: 3.9; *Icon* SUS = 4.2). Most participants also reported they would use SMART Note frequently if it were available (*Combination* SUS: 4.1; *Icon* SUS = 4.3). SUS ratings for the *Icon* prototype improved slightly for all items except “*I think that I would use this system frequently,*” which stayed the same. Additionally, in this round, the *Icon* prototype scored the same or slightly better than the *Combination* prototype on all but one SUS item, “*I needed to learn a lot of things before I could get going with this system.*” In this round of testing, none of the participants added comments to their SUS forms. Figure 5.19 displays average responses to the SUS for each of the Round Two prototypes.

For both the *Combination* and the *Icon* medium-fidelity prototypes, performance improved for all of the problem areas that arose in Round One. Participants collectively achieved a 70% success rating or higher for all tasks with both prototypes. In a few cases,

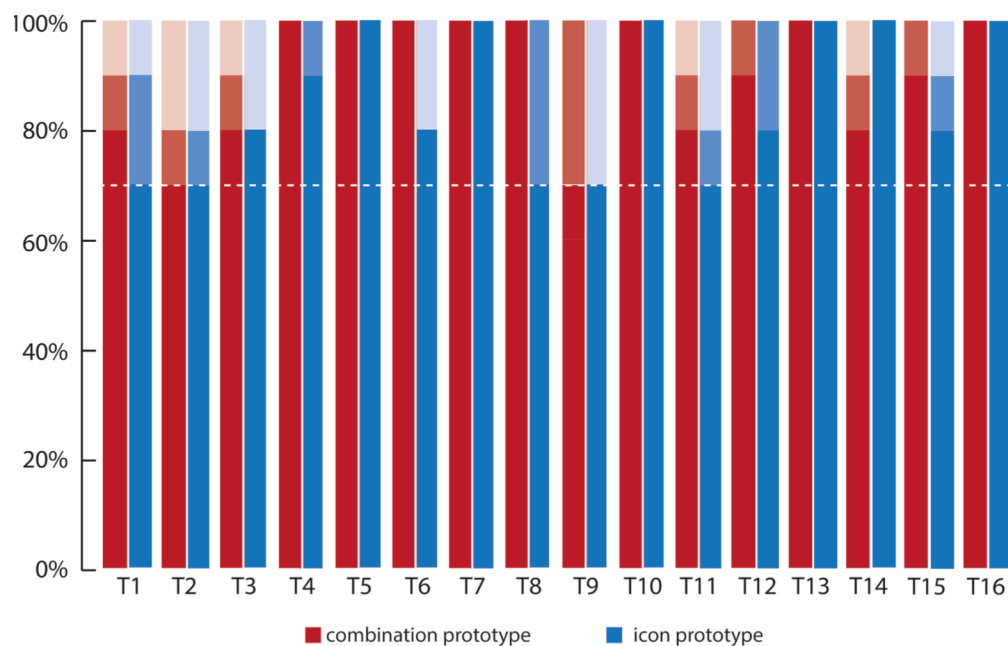


**Figure 5.18. Participants rated how useful they perceived each of the SMART Note annotation features to be on a five-point Likert Scale (five, very useful; one, very un-useful).**

### Average System Usability Ratings - Round Two



**Figure 5.19. Average responses to the Systems Usability Scale (SUS) for each of the Round Two prototypes**



**Figure 5.20. Success rates for combination and icon prototypes in the second round of testing**

participants struggled at first to articulate the meaning of a few icons. Figure 5.20 illustrates success ratings for each task in the second round of testing for both the combination and icon wireframes.

***Medium-fidelity combination prototype.*** In the redesigned prototype, the Concept Map Study Guide button labeled “My Notes” improved participants’ ability to understand its function (80% success rate, Task 1; 100% success rate, Task 10). Likewise, the redesigned key term capture button led to improved performance (100% success rate, Task 5). Finally, the addition of a segmented progress bar improved participants’ ability to understand video segment capture’s meaning and purpose (80% success rate, Task 3).

***Medium-fidelity icon prototype.*** In the redesigned prototype, the Concept Map Study Guide button was changed to look like an actual notebook. This improved users’ understanding (70% success rate, Task 1; 100% success rate, Task 10), and most users said they preferred this approach to the “My Notes” label offered in the combination prototype. Additionally, the new video key term capture design also improved participants’ understanding (70% success rate, Task 8). Finally, the addition of visual feedback improved participants’ understanding of video segment capture (80% success rate, Task 3).

#### 5.3.2.3 Discussion

For both wireframe prototypes tested in the first round, users struggled most with articulation tasks that involved describing the meaning and function of certain icons. Specifically, the most problematic icons—video segment capture, key term capture, and Concept Map Study Guide navigation—were very difficult for users to grasp. Although it is not surprising that users would struggle to explain features they are not familiar with, this did raise the question of just how much visual feedback and/or on-screen labeling users need to fully understand the meaning and function of such features. For example, users clearly needed more feedback to understand not only what the segment capture button does, but also how it works in concert with the video as it plays. Thus, redesigns of both prototypes for the second round of testing allowed for experimentation with two different degrees of visual feedback. In the *Medium-Fidelity Combination Prototype* each video segment was identified with a label that highlighted when the corresponding



segment was playing (Figure 6.12b). In the Medium-Fidelity *Icon Prototype*, a video timeline was added that was divided into colored segments. Each part of the line highlighted as the corresponding segment played (Figure 6.12e). In both cases, learners were more immediately able to articulate what was happening and see the relationships between the highlighted label or segment, the video capture button, and the video itself. Similar visual and textual affordances were added to the key term capture button to give learners a few more clues as to their meaning and function, which also improved task performance.

In addition, participants' positive feedback regarding the perceived usefulness of each SMART Note annotation feature was also promising. Likewise, the Concept Map Study Guide *map view* feature was rated higher in terms of perceived usefulness than *list view*, suggesting that a hierarchical structure for annotations that follows the topical sections of a chapter may facilitate a more intuitive organizational structure. Overall, the generally high success ratings across all prototypes in the first two rounds of testing suggested that the SMART Note conceptual and interaction designs provide a sound user experience. Likewise, iterative design, development, and usability testing provided a foundation for three subsequent studies that compare annotation features and active reading support between SMART Note and existing tablet textbook systems and frameworks. These comparative evaluations are reported in the chapters that follow.

First, Chapter 6 outlines an analytical evaluation of SMART Note annotation features that explored the operational framework for an efficiency model for user performance. A modified Keystroke Level Model evaluated expert performance for both SMART Note and Inkling Habitat, the leading tablet textbook platform currently on the market. Chapter 6 also includes a final usability study on a fully functional SMART Note prototype. Later, Chapter 8 reports on a study that assessed how SMART Note compares to a "Baseline prototype" that emulated Inkling Habitat annotation features on learning experience, process, and outcomes. A complete set of screen shots for both the SMART Note and Baseline prototypes are provided in Appendix B.

## **6 Comparative Analytical and User Experience Evaluation**

Supporting active reading in the tablet environment is a much more complex endeavor than simply providing different types of interaction tools. Rather, one must first consider the strategies and activities users wish to enact during the unique experience of reading with the intent to learn. Thus, SMART Note represents the embodiment of novel active reading techniques to support learning with multimedia in tablet textbooks. SMART Note was carefully designed based on early research that discovered that learners often struggle to make sense of and subsequently remember content delivered in multiple media formats, are distracted by the mechanics of interactive content, and grapple with the transient nature of audiovisual material.

The following studies were conducted to assess how well SMART Note supports learners in their active reading goals compared to features offered by tablet textbook platforms currently available. Thus, Inkling Habitat, the leading tablet textbook platform on the market, was chosen as a baseline control system. Three different comparative evaluations were conducted to collect a full range of data that assesses the fundamental properties of active reading support. The first study implemented a modified Keystroke-Level Model (KLM) evaluation to compare SMART Note annotation features and techniques to Inkling annotation features and techniques in terms of efficiency, usability, and perceived appropriateness for learners. The second study was a usability evaluation with 10 participants to empirically evaluate the active reading support offered by SMART Note annotation features and techniques compared to a baseline prototype that emulates Inkling Habitat annotation features and techniques. Qualitative and quantitative user feedback on the nature and appropriateness of the study tools, as well as perceived efficiency of active reading tasks are addressed. Finally, the third study evaluated SMART Note in an actual study session to assess both learning outcomes on a complete textbook chapter (through quizzes) and the overall study experience compared to existing tablet textbook active reading tools.

### **6.1 Analytical evaluation: Assessing keystroke-level efficiency**

An analytical evaluation implemented a modified Keystroke Level Model (KLM) (Card, Moran, & Newell, 1983; Kieras, 2001) to test the operational framework for the

SMART Note design and provide an efficiency model for user performance. With a few modifications to accommodate unique touch screen scenarios and interaction patterns, the Keystroke-Level Model for task analysis is suitable for evaluating touch interaction with mobile devices (Holleis, Otto, Hussmann, & Schmidt, 2007; Mori, Matsunobe, & Yamaoka, 2003; Schulz, 2008). The KLM evaluation compared SMART Note and Inkling interaction patterns for seven key active reading tasks. The modified KLM was also used to evaluate expert performance on the same tasks in Inkling Habitat, the leading tablet textbook platform currently on the market. The KLM protocol facilitated measurement of SMART Note efficiency based on the time, number of tap/swipe interactions, and number of steps it takes expert users to execute key active reading tasks in each environment.

#### ***6.1.1 Keystroke level modeling for task evaluation***

The KLM was originally designed as a straightforward, easy-to-implement method for estimating the time it takes to complete simple input tasks on desktop systems. KLM can be used to analyze the steps required to complete a specific task and subsequently rearrange or eliminate unneeded steps. Modified versions of KLM have been used to evaluate individual systems (Abdulin, 2011) as well as compare one system to another (Schulz, 2008) in an effort to determine which is more efficient. Several researchers (Holleis et al., 2007) have found that with a few modifications to accommodate unique touch screen scenarios and interaction patterns, KLM is suitable for evaluating touch-based interactions with mobile devices. Thus, KLM provides an effective method for identifying key operators necessary to complete active reading tasks and report time-on-task, the number of touch interactions (e.g., tapping and swiping), and the number of steps specific active reading tasks require.

The KLM study compared SMART Note and Inkling interaction patterns for seven key active reading tasks. Each task was designed to illustrate the steps learners must take to annotate and review annotations made using the SMART Note annotation tools versus existing Inkling tools. This comparison is a useful way to test whether SMART Note tools improve task efficiency by requiring less time and fewer steps and touch interactions to achieve desired active reading goals. This evaluation is also

important for understanding the key contributions SMART Note makes to active reading support.

### **6.1.2 Stimuli**

#### **6.1.2.1 SMART Note**

The SMART Note design was applied to an educational chapter on photosynthesis that replicated content in a 100-level Biology text. The chapter included text (about 2,500 words), three video animations (two- to six-minutes long), and two interactive graphics.

#### **6.1.2.2 Inkling Habitat**

Inkling Habitat ([www.inkling.com](http://www.inkling.com)) was chosen for this comparative evaluation because it is the best known and most widely adopted publishing platform for digital textbooks (Reid, 2014) and features the most comprehensive active reading support to date. In 2011, Pearson Education partnered with Inkling to test-drive new interactive textbooks at several universities (Coombs, 2011) and re-imagine the traditional textbook to provide students with a more robust multimedia experience. Likewise, in 2014, McGraw-Hill Education selected Inkling Habitat, for building McGraw-Hill Education's next-generation learning products and tablet textbooks (Hebbard, 2014) Inkling books boast a number of active reading features, including the ability to highlight text, take notes, and explore clickable keywords; bookmark pages and sections of a text, as well as mark helpful notes others have posted in social learning network; and browse collections of highlighted text, notes, reading history, and glossary terms. In 2014, *Fast Company* named Inkling one of the World's 50 Most Innovative Companies.

Inkling does not offer comparable counterparts to most of SMART Note's novel active reading features. However, in all cases, a determined active reader could execute similar functionality in existing systems through reasonable workarounds. Thus, to provide a practical comparison between SMART Note and Inkling active reading support, reasonable alternative actions to each SMART Note feature were identified for the Inkling platform. In all cases, the Inkling alternative represents the quickest and most straightforward way to complete a specific active reading task in the Inkling

Operation		Description	Suggested avg. values
<b>K</b>	Keystroking	Pressing a key on the touch screen keyboard (based on average skilled typist-55 wpm)	0.20 sec
<b>P</b>	Pointing	Moving the finger to a target on the screen	0.50 sec
<b>B</b>	Button tapping	Tapping any single button on the screen	0.10 sec
<b>P/H</b>	Press & hold	Touch screen method for activating popup with built-in commands	1.00 sec
<b>H</b>	Homing	Clicking on a field that requires text input and moving hands to the keyboard	0.40 sec
<b>M</b>	Mental	Mental preparation or thinking	1.20 sec
<b>S</b>	Swiping	Swipe (draw) straight path segment with finger 10 centimeters in length	1.20 sec

**Table 6.1. The KLM-GOMS approach used for this study was adapted from (Kieras, 1993).**

environment. KLM tasks were executed using a chapter of an existing Inkling biology textbook.

### **6.1.3 Procedure**

First, one expert user executed each operator task 10 times to ensure average operation times were accurate. The keystroke (K), button tapping (B), homing (H), and mental (M) operators were not changed, as these estimates are equally acceptable for touch screen tablet interaction. The pointing (P) operator time was shortened to account for the smaller screen size, which makes moving a hand or finger to a target on the screen a slightly faster action (Schulz, 2008). One operator—press and hold (P/H)—was added to reflect a touch screen-specific interaction pattern relevant to this study. Press and hold is a standard iOS and Android feature that, when used, shows all the possible actions users can take on the target object. For tablet textbooks, the most common application of press and hold triggers a pop up with a list of options (e.g., highlight or add a note) for a specific target (e.g. word, image, label). The system response time for this action is built into the suggested average value. Finally, the swiping (S) operator was adapted from Kieras’ draw (D) operator, and the time associated with this operator was estimated based on the time it takes to swipe along a straight, 10-centimeter path on the touch screen. Only KLM operators relevant to the tablet textbook features studied were included in this evaluation (Table 6.1).

Next, seven active reading tasks that correspond with each of the seven key SMART Note annotation features were identified. The tasks grew from the requirements and were based on results from a prior study that uncovered key active reading strategies learners wanted to enact in the tablet environment. The series of steps required for completing each task in SMART Note and then Inkling was also identified. Then, the appropriate mental or keystroke operators were determined for each step and time values were assigned to KLM operators. Times for operators were added together to determine the expert time on task for each active reading task. This method assumes that operator times are invariant and do not depend on the previous sequence of events. A complete list of the actual steps required to complete each task can be located in Appendix C.

#### **6.1.4 Results**

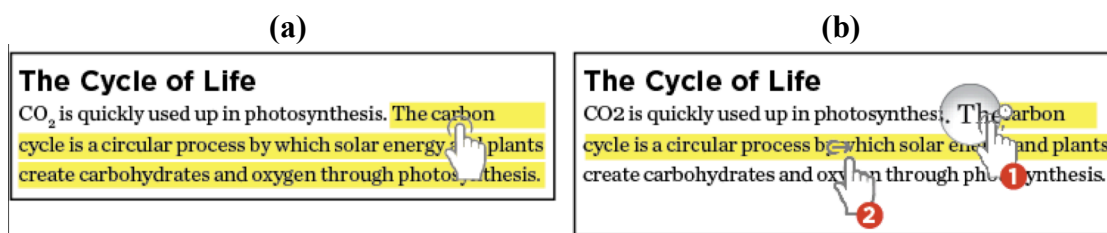
For all seven active reading tasks, the SMART Note design features took less time and required fewer touch interactions (i.e., keystrokes, button taps, finger swipes) and steps to execute than the alternative actions in Inkling. SMART Note also minimizes the interaction mechanics required for each active reading task. In most cases learners can achieve a particular active reading goal with a single button tap instead of multiple button taps and/or imprecise swiping necessary to reach the same active reading goal in Inkling. Table 6.2 displays the times, number of keystrokes, and total number of steps required for seven key active tasks for both the SMART Note and Inkling interfaces. The sections that follow chronicle the analysis for each active reading task and elaborate on the specific actions required to achieve each active reading goal.

##### *6.1.4.1 Task One: Highlighting text for future review*

Highlighting words, phrases, and sentences in a textbook is a common learner activity. Thus, all tablet textbook platforms and some other applications allow users to highlight static text and add notes to those highlights. In the Inkling framework (and several others), any highlighted block of text is then saved to a built-in notebook through a “tap-and-swipe highlighting” process (Figure 6.1a). Alternatively, one-tap highlighting in SMART Note (Figure 6.1b) allows learners to highlight at the sentence level by tapping any part of a single sentence. In both interfaces, learners can also add a note with

Tasks	KLM Operators	
	SMART Note	Inkling
<b>Task 1.</b> Highlight a sentence; then add a note to it.	<i><b>One-tap highlighting</b></i> 8.2 seconds 1 touch interaction/2 steps <i><b>Add a note</b></i> 14.4 seconds 60 touch interactions/5 steps	<i><b>Tap-and-swipe highlighting</b></i> 12.2 seconds 2 touch interactions/3 steps <i><b>Add a note</b></i> 15 seconds 61 touch interactions/6 steps
<b>Task 2.</b> Save a key term and definition for future review.	<i><b>Key term capture</b></i> 10.5 seconds 3 touch interactions/5 steps	<i><b>Manual key term entry</b></i> 43.5 seconds 153 touch interactions/10 steps
<b>Task 3.</b> Save a portion of a video for future review; then review the annotation in the tablet notebook.	<i><b>Video segment capture</b></i> 1.8 seconds 1 touch interaction/2 steps <i><b>Video segment review</b></i> 33.6 seconds 4 touch interactions/5 steps	<i><b>Bookmark and manual scrubbing</b></i> 4.6 seconds 7 touch interactions/7 steps <i><b>Bookmark review</b></i> 36.0 seconds 5 touch interactions/6 steps
<b>Task 4.</b> Save a key term mentioned in a video for future review.	<i><b>Video key term capture</b></i> 1.8 seconds 1 touch interaction/2 steps	<i><b>Manual video key term entry</b></i> 34.8 seconds 150 touch interactions/9 steps
<b>Task 5.</b> Add a note to the 48-second mark; then review the annotation in the tablet notebook.	<i><b>Video point annotation</b></i> 22.0 seconds 92 touch interactions/6 steps	<i><b>Manual time stamp</b></i> 24.8 seconds 99 touch interaction /10 steps
<b>Task 6.</b> Save a sentence from audio to the tablet notebook and attach a note to it.	<i><b>Video transcript annotation</b></i> 14.2 seconds 45 touch interactions/8 steps	<i><b>Manual transcription</b></i> 37.8 seconds 149 touch interactions/14 steps
<b>Task 7.</b> Add a note to a static image.	<i><b>Image capture and annotation</b></i> 15.6 seconds 60 touch interactions/6 steps	<i><b>Image annotation</b></i> 17.4 seconds 63 touch interactions/9 steps

**Table 6.2. SMART Note yields savings of time, touch interactions, and steps over Inkling for all tasks. In most cases, an equivalent feature does not exist in the Inkling interface. Thus, reasonable alternative actions were identified for each task to reach the desired goal with the fewest number of steps and touch interactions and the shortest amount of time.**



**Figure 6.1a. To highlight a sentence in Inkling,  
(1) tap and hold on the first word of the desired sentence, (2) swipe finger across  
the length of the sentence and release after the last word.**

**Figure 6.1b. To highlight a sentence in SMART Note,  
tap any part of the sentence.**

the tap of a button. For this analysis, a single sentence from the photosynthesis chapter was identified. Additionally, the following personalized annotation was used for calculating time to add a note to highlighted text: *Carbon cycle = solar energy + plants = carbohydrates & O<sub>2</sub>* (58K). The research task was to *highlight the sentence; then add a personalized note to it*. SMART Note interaction resulted in a savings of 1 touch interaction and 1 step to capture the desired sentence. Likewise, the task took 4.0 seconds less time to execute in SMART Note than Inkling. Additionally, SMART Note interaction resulted in a savings of 1 touch interaction and 1 step to add a personalized note to the highlighted sentence, and adding a personalized note took 0.6 seconds less time to execute in SMART Note than Inkling. Although the savings may seem small as applied to one task, in an actual active reading session these numbers must be multiplied by the number of sentences highlighted. The chapter used for this analysis included about 225 total highlight-able sentences. Added together, the total number of sentences a student chooses to highlight could amount to several minutes of time saved and several fewer instances of distraction from reading.

#### 6.1.4.2 Task Two: Saving a key term and definition

Most interactive textbooks also include bolded key terms that learners can tap to view a definition. However, for most tablet textbook platforms–Inkling included–there is no way to save individual key terms to the notebook. To address this, SMART Note’s key term capture (Figure 6.2) allows learners to save those terms and definitions to the Concept Map Study Guide with the tap of a button. Although no equivalent function



exists in the Inkling interface, a learner could transcribe definitions into the Inkling notebook. Thus, “manual key term entry” (Figure 6.3) is identified as the relevant alternative action.

The following single key term and definition from the photosynthesis chapter was

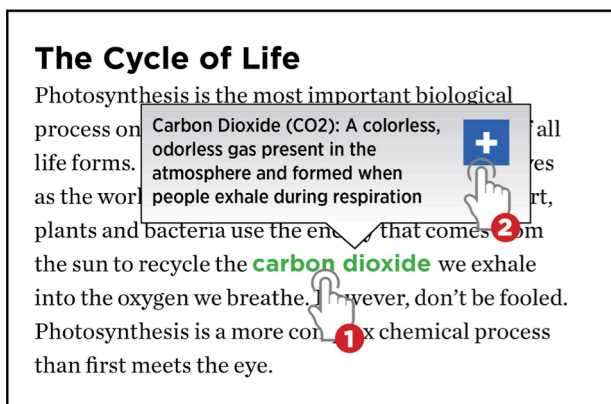
chosen for this task analysis:

*Thylakoid: A membrane-bound compartment inside chloroplasts and cyanobacteria that are the site of the light-dependent reactions of photosynthesis* (147K). The research

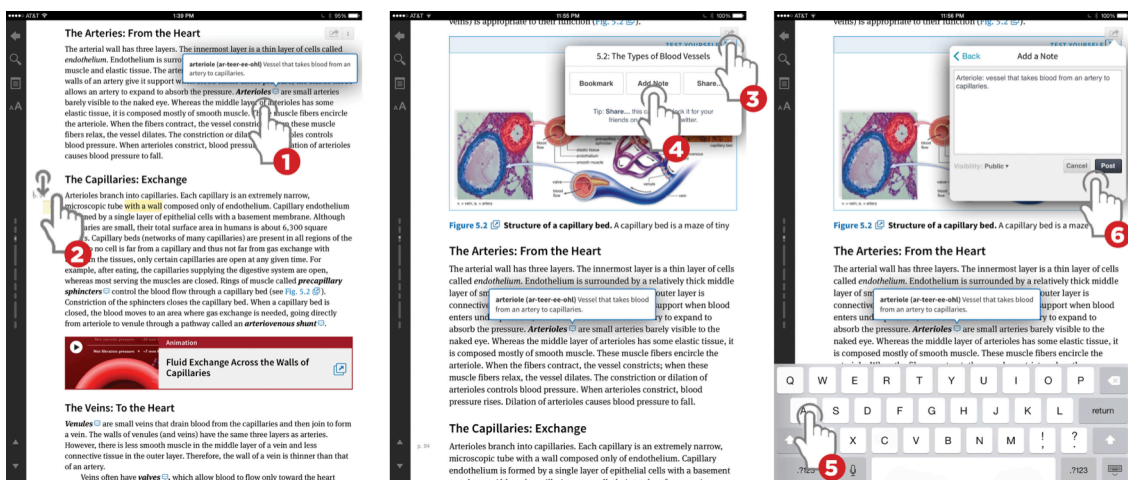
task was to *save a key term and definition for future review*. SMART Note interaction resulted in a savings of 150 touch interactions to capture the transcribed sentence and 5 steps to complete the task. Likewise,

overall this task took 33.0 seconds less time to execute in SMART Note than Inkling.

This represents a significant savings of time and interaction that grows exponentially with

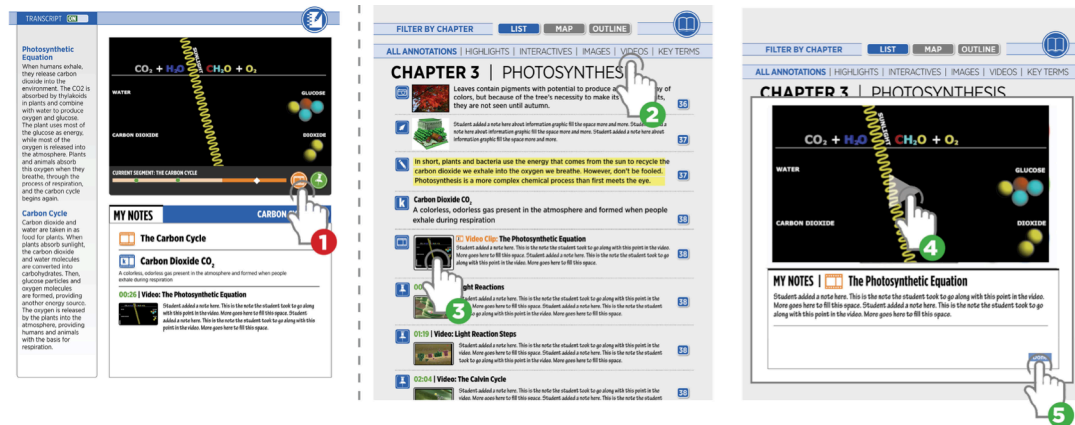


**Figure 6.2.** To view and save a key term and its definition in SMART Note,  
(1) tap key term to activate popup;  
(2) tap “+” button to add the key term and definition to Concept Map Study Guide.



**Figure 6.3.** To view and manually save a key term in Inkling,  
(1) tap key term to activate popup, (2) swipe page so key term popup remains visible, (3) tap annotate button, (4) type *Add Note*,  
(5) type key term and definition, (6) tap *Post*.

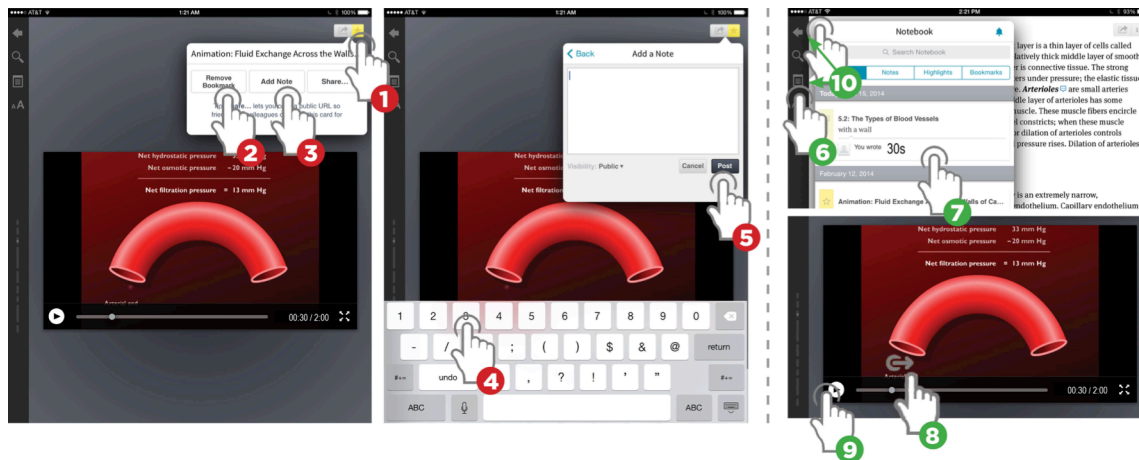
the number of key terms and definitions a learner chooses to capture. Additionally, because learners are able to capture a key term and definition with a simple button tap instead of manual entry, they are less likely to be taken out of the flow of reading or distracted from the substance of the material.



**Figure 6.4. To capture a video segment in SMART Note, (1) tap segment capture button; video segment review interaction pattern (2) tap *Videos* filter to see all video annotations, (3) tap annotation for desired video segment (4) tap play button to watch video segment, (5) tap *Done* to return to Concept Map Study Guide.**

#### 6.1.4.3 Task Three: Saving Part of a Video for Future Review

Videos often contain important information for learners to annotate and review. However, Inkling and other tablet textbook systems only allow learners to bookmark and add notes to a whole video. Alternatively SMART Note's video segment capture (Figure 6.4) allows learners to save shorter segments of longer videos for future review with the tap of a button. As the video plays, the bar below it indicates the learner's progress through predetermined segments in the video, as well as progress through the current segment. If at any time learners wish to save a segment for future review, they only have to tap the orange segment capture button and the segment will be saved to the Concept Map Study Guide. Although a parallel feature does not exist in Inkling, a learner could "bookmark" a video to save it to the Inkling notebook. Then, the learner could add a time stamp that corresponds with the starting point of the desired video segment using the "add note" button. Finally, to review the video segment, the learner would have to manually scrub across to the starting point for a particular segment before playing it.



**Figure 6.5. To bookmark and manually time stamp a video segment in Inkling, (1) tap annotate button, (2) tap *Bookmark*, (3) tap *Add Note* (4) type time stamp (5) tap *Post*; video segment review interaction patterns: (6) tap notebook button, (7) tap desired video segment (8) swipe across scrubber to the 30-second mark, (9) tap play button to watch video, (10) tap notebook button to return to annotations or arrow button to return to the body of the book.**

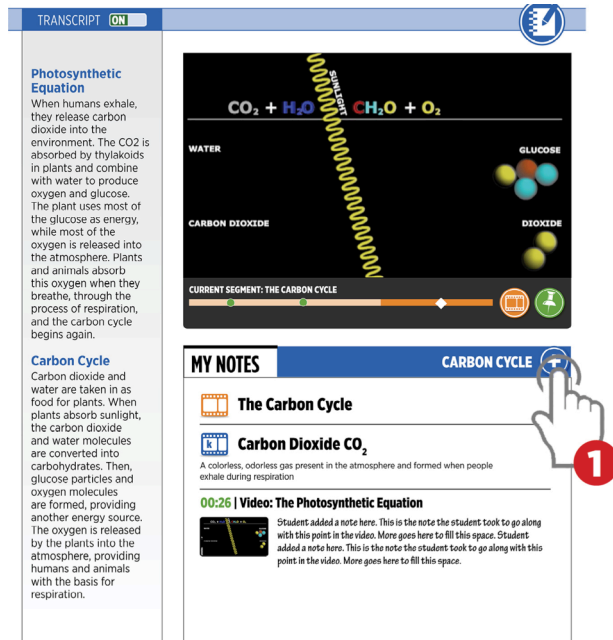
Thus, “video bookmark and manual scrubbing” (Figure 6.5) is identified as the relevant alternative action in Inkling.

To illustrate these interactions, a two-minute video in each interface was selected. The SMART Note video was divided into four logical segments, each of which was 30 seconds long. The second 30-seconds in the Inkling video was chosen as the “test segment” for the KLM analysis. The research task was to *save a portion of a video for future review; then review the annotation in the tablet notebook*. SMART Note interaction resulted in a savings of 6 touch interactions and 5 steps to complete the first part of the task. Moreover, it took 2.8 seconds less time to execute in SMART Note than Inkling. To review a video segment captured in SMART Note’s Concept Map Study Guide, the learner must only find the annotation and tap it. However, to do so in Inkling, the learner must swipe across scrubber to find the desired starting point. In this case, SMART Note interaction resulted in a savings of 1 touch interaction and 1 step to complete the task. Overall this task took 2.4 seconds less time to execute in SMART Note than Inkling. Additional swiping (S) actions, finger pointing (P), and button tapping (B) could also occur if the learner has trouble finding the desired starting point or must rewind to watch the segment more than once. Thus, video segment capture represents a

significant savings of time and potential distraction associated with cumbersome mechanical interaction that does not contribute to learning.

#### 6.1.4.4 Task Four: Saving a key term mentioned in a video

Like narrative text that includes key terms and definitions, videos and animations often contain key terms defined aurally in the accompanying audio track. SMART Note's



**Figure 6.6. To save a key term and its definition mentioned in a video in SMART Note, (1) when key term is mentioned in the video and appears on screen, tap “+” button to add the key term and definition to Concept Map Study Guide.**

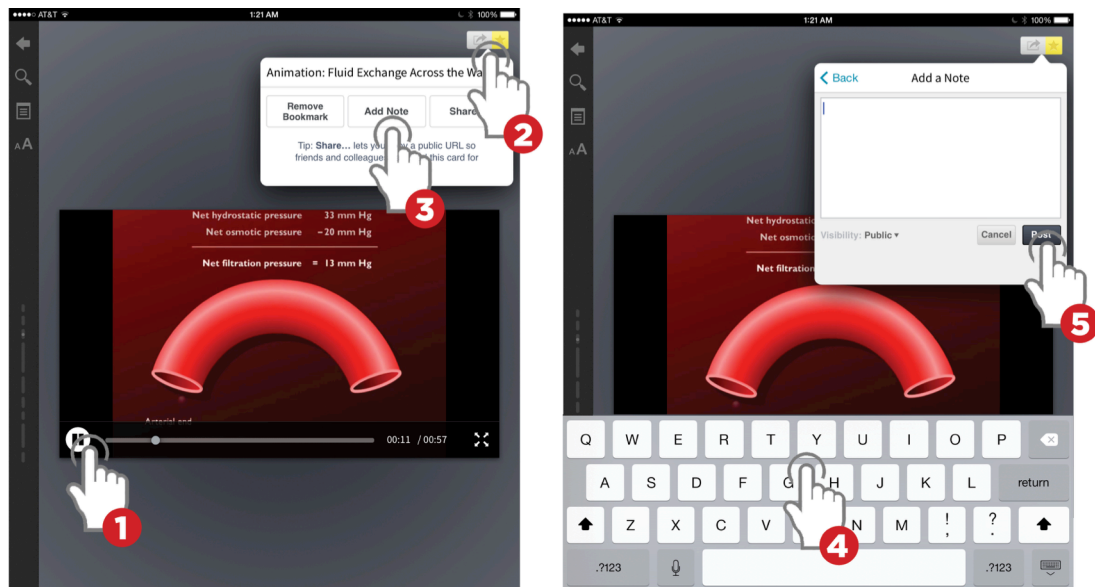
video key term capture (Figure 6.6) allows learners to save those terms and corresponding definitions for future review with the tap of a button. When key terms are mentioned in a video, they display on the screen for a short period of time. The key term and its definition are automatically saved to the Concept Map Study Guide when the learner taps the “+” button next to the word(s). No equivalent function exists in the Inkling interface.

However, a learner could use the note-taking function in Inkling to manually enter a key term and its definition to the Inkling notebook.

Thus, “manual video key term entry”

(Figure 6.7) is identified as the relevant alternative action for Inkling users.

One key term with an average-length definition was chosen for task analysis: *Photosystems: Proteins in chlorophyll that capture light energy*. The research task was to *save a key term mentioned in a video for future review* (145K). SMART Note interaction resulted in a savings of 149 touch interactions to capture the key term and definition and 7 steps to complete the task. The task took 33.0 seconds less time to execute in SMART Note than Inkling. Granted, a learner may choose to shorten the definition when taking



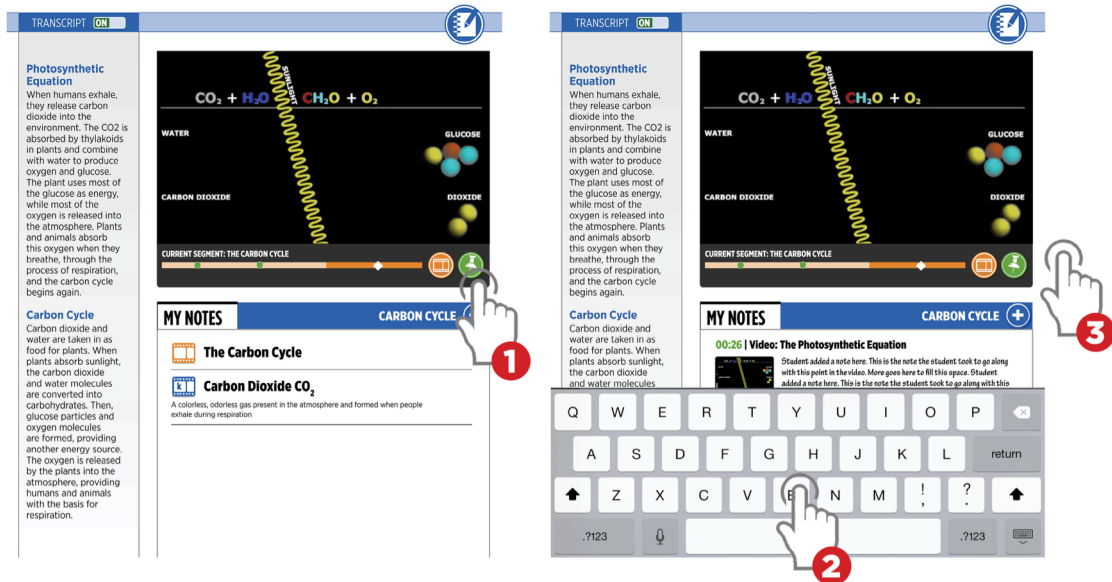
**Figure 6.7 To manually save a key term and its definition in Inkling, (1) tap *pause* to stop video, (2) tap *annotate* button, (3) tap *Add Note* (4) type key term and definition (5) tap *Post*.**

notes, which would result in fewer touch interactions and time on task. However, some degree of efficiency is gained in SMART Note because the key term can be captured with one tap instead of through manual transcription. Again, automatic, vs. manual key term capture represents significant time and interaction savings, as well as potentially detrimental distractions from watching and learning from a video.

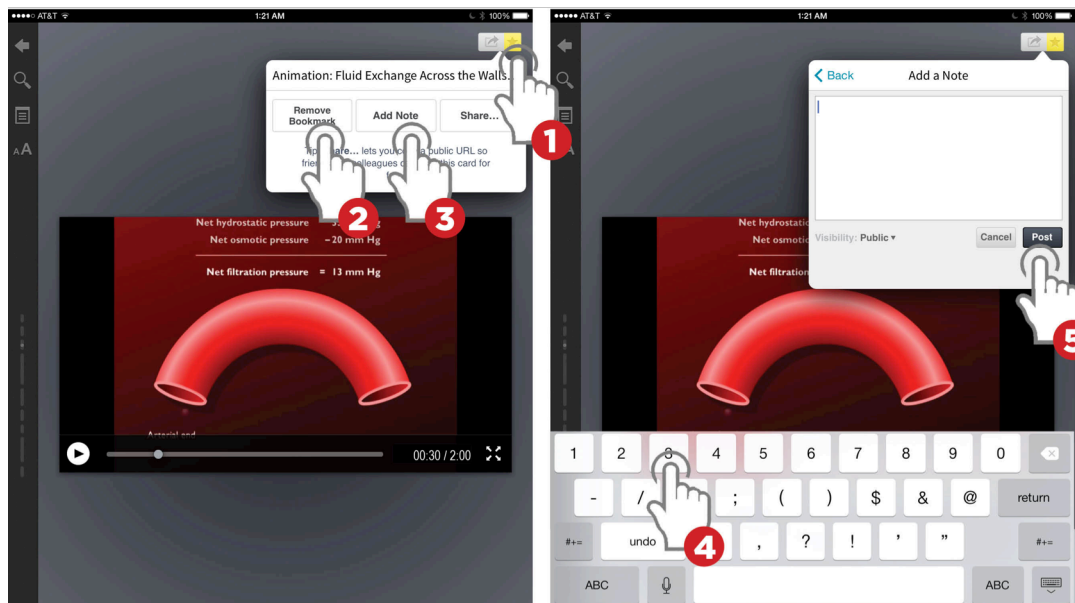
#### *6.1.4.5 Task Five: Adding a personalized note to a point in a video*

A learner may also wish to add personalized notes to a video that are tied to a certain point in the video's timeline. SMART Note's video point annotation (Figure 6.8) makes this possible. At any point while a video is playing, learners may tap the green point annotation button to pause the video while they type a note. That annotation is then connected to the point at which the video was paused so that learners can return to that part of the video later by tapping the annotation that appears in the Concept Map Study Guide. No equivalent function exists in the Inkling interface. However, a learner could use the "add note" feature in Inkling to manually add to the video a time stamp and personalized note. To review the video later, the learner could then use the scrub bar to advance the video to the time indicated in the time stamp. Thus, "manual time stamp"





**Figure 6.8. To annotate a point in a video timeline in SMART Note, (1) tap “key term capture” button (2) type annotation, (3) tap anywhere in the margin of the page to resume video and hide keyboard.**



**Figure 6.9. To manually time stamp a video annotation in Inkling, (1) tap annotate button, (2) tap *Bookmark*, (3) tap *Add Note* (4) type time stamp (5) tap *Post*.**

(Figure 6.9) is the relevant alternative action to SMART Note’s video point annotation feature.

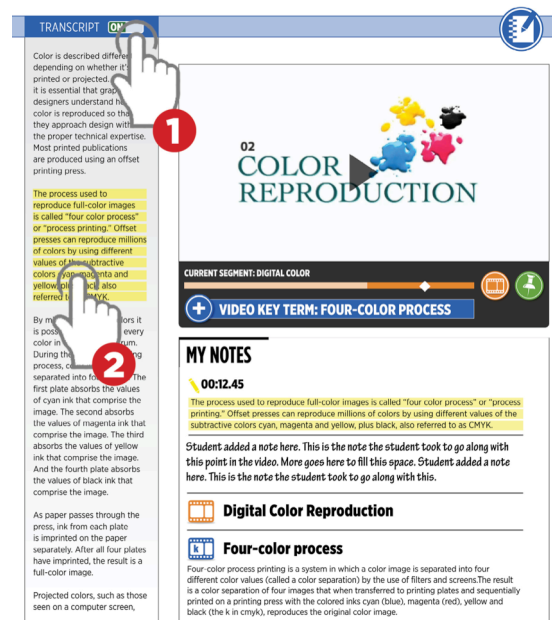
For this task analysis, the following simple annotation was identified for a video in the photosynthesis chapter: *Phase One: “light reactions” – light energy is converted to*

*chemical energy in thylakoids* (90K). This annotation would logically be added around the 48-second mark in a three-minute, 36-second video. In this case, the research task was to *add a personalized note to the 48-second mark; then review the annotation in the tablet notebook*. SMART Note interaction resulted in a savings of 7 touch interactions and 4 steps to complete the task. Likewise, overall this task took 2.8 seconds less time to execute in SMART Note than Inkling. Like video segment capture, reviewing a video annotation in Inkling requires the learner to manually scrub along the timeline to the desired starting point, resulting in additional keystrokes, steps, and time.

#### 6.1.4.6 Task Six: Annotating audio

Important information is often delivered in the audio voiceover that accompanies a video or animation. The SMART Note interface provides a dynamic text version of audio accompanying all videos or animations (Figure 6.10). The learner can choose to make this video transcript visible or invisible during active reading, and when it is visible, it can be highlighted and/or annotated just like narrative text found in the body of the chapter using the “one-tap highlighting” and “add a note” features. No equivalent function exists in the Inkling interface, as audiovisual transcripts are not provided. However, a learner could use the “add note” function in Inkling to manually transcribe audio content. Thus, “manual transcription” is identified as the relevant alternative action to SMART Note’s video transcript annotation feature. The “add note” feature is shown in Figure 6.9.

To illustrate these interaction patterns, the following single sentence in the Photosynthesis chapter was chosen for



**Figure 6.10. When the video transcript is visible in SMART Note (1), audio text can be highlighted and/or annotated (2) just like narrative text found in the body of the chapter using the “one-tap highlighting” and “add a note” features.**



**Figure 6.11. To mark and annotation an image in SMART Note, (1) tap “+” button to save a static image and its caption, (2) type annotation, (3) tap anywhere in the margin to hide the keyboard.**

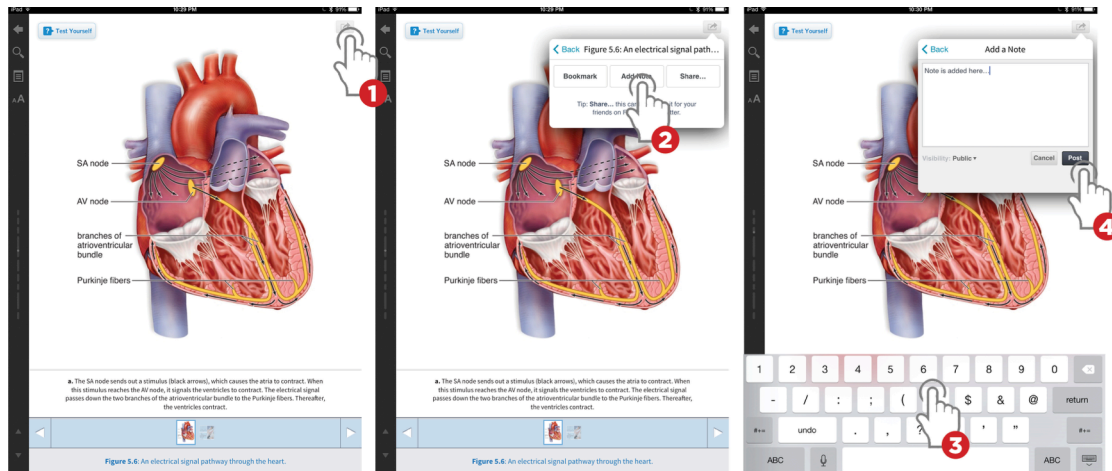
this task analysis: *The  $CO_2$  is absorbed by thylakoids in plants, which combine with water to produce oxygen and glucose (100K).* The research task was to *save a sentence from the audio to the tablet notebook and attach a personalized note to it.* SMART Note interaction resulted in a savings of 104 touch interactions to capture the transcribed sentence and 6 steps to complete the task. Likewise, this task took 23.6 seconds less time to execute in SMART Note than Inkling. Because Inkling provides no option for annotating transcripts, the efficiency gain associated with annotating audiovisuals in SMART Note is significant, and distracting mechanical overhead is eliminated.

#### 6.1.4.7 Task Seven: Adding a personalized note to an image

Like videos and text, static images also contain valuable information for students to annotate and study. SMART Note’s image capture and annotation feature (Figure 6.11) allows learners to add notes to static images or individual frames of interactive graphics, charts, and diagrams. To do so, a learner taps the “+” button associated with an image, which activates the touch screen keyboard for note taking. A similar “image annotation” feature (Figure 6.12) exists in Inkling. However, no visual cue accompanies the annotation in the Inkling notebook.

For this task analysis, the following simple personalized annotation was conceived to accompany an image in the Photosynthesis chapter: *Green pigments = nutrients; brown pigments = no nutrients (59K).* Thus, the research task was to *add a*





**Figure 6.12. To mark and annotate an image in Inkling, (1) tap annotate button, (2) tap *Add Note* (3) type annotation (4) tap *Post*.**

*note to the static image.* SMART Note interaction resulted in a savings of 3 touch interactions and three steps to complete the task. Likewise, overall this task took 1.8 seconds less time to execute in SMART Note than Inkling. Although SMART Note eliminates a few steps required to make an image annotation these results are less significant because the image annotation features in both systems are relatively similar.

### 6.1.5 Discussion

These task-based KLM and usability studies demonstrate that SMART Note offers a more efficient set of tools than an existing platform for engaging in active reading in the tablet environment. In addition to the fact that SMART Note performed better for time on task and the number of steps and touch interactions required to complete each active reading task, a few additional observations are important.

First, for several tasks, the efficiency gains were quite large. For example, easily capturing key terms and definitions or transcribing information delivered aurally in videos is not possible in the Inkling interface. Rather, the learner must manually type that information, which is both time-consuming and cumbersome. By replacing manual transcription with one-tap key term capture and by providing transcripts for audiovisual content, the learner gets a much quicker and less distracting way to annotate that information. The cumulative effect of this efficiency gain will be significant when

applied to a complete active reading session during which a learner collects numerous key terms/definitions and annotates several video presentations.

Second, although in some cases, efficiency gains were minimal, it is important to note that comparatively, reasonable workarounds in Inkling are generally more complex and require more precision on the part of the learner than SMART Note features. Thus, the elimination of a few specific and complex touch interactions could lead to significant improvements in time, distraction, and subsequent frustration on the part of the learner. For example, although SMART Note's video segment capture only results in a 2.8 second gain when it comes to time on task, six touch interactions are eliminated by allowing learners to save a video segment with a single button tap. For this task (as well as Task 5) additional swiping (S) actions, finger pointing (P), and button tapping (B) could also occur if the learner has trouble finding the desired starting point for a segment or point or if the learner must rewind to watch a segment more than once. Likewise, for some tasks, additional mental processing (M) could be necessary. For example, if learners must manually transcribe information found in audiovisuals, it is possible they will have to re-listen to a portion of audio in order to remember it. Again, the cumulative effect of these efficiency gains will be larger when applied to a complete active reading experience.

Third, one of the limitations of using a modified KLM for this task inspection is that it is based on an expert user and therefore assumes a learner could easily envision appropriate workarounds when their active reading goals aren't supported. Furthermore, KLM assumes that the learner would quickly become adept at implementing those workarounds. It is much more realistic to assume that if a learners' active reading goals aren't supported, they will quickly become frustrated. Although a skilled active reader would likely find ways to work around the system, the cumulative inefficiency and potential distractions could still hinder learning.

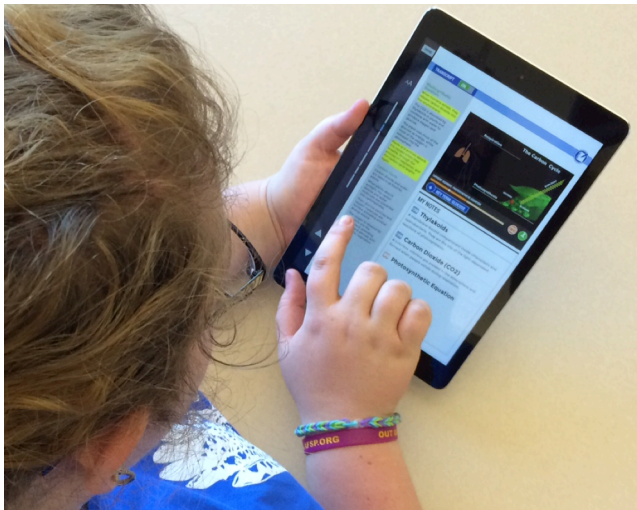
## **6.2 User evaluation: Assessing usability and appropriateness of active reading support**

Usability testing was also conducted with 10 participants to collect feedback regarding the interaction patterns required to engage in active reading. Feedback from the

first two rounds of iterative design and usability testing informed the development of a fully functional final high-fidelity prototype of the SMART Note system. Additionally, because Inkling Habitat is a closed system, a second “Baseline Prototype” that emulated Inkling Habitat annotation features was created to maintain consistency of subject matter. Again, a task-based inspection explored usability and user experience both SMART Note and the Baseline systems. Both prototypes were applied to an educational chapter on photosynthesis that replicated content in a 100-level Biology text. The chapter included text (about 2,500 words), two video animations (2- to 6-mins. long), and two graphics. Evaluation was conducted on an Apple iPad 3. Both evaluations targeted specific active reading strategies through task-based usability research based on rigidly defined tasks that exposed participants to all of the key features in each system. This experiment has been approved by IRB #IRB-557346-1. Following is a detailed explanation of procedures and results.

### ***6.2.1 Participants and procedure***

Ten undergraduate or graduate students (aged 18-26; 5 male, 5 female) at a mid-sized Midwestern University were recruited to participate in the user experience



**Figure 6.13. Participants completed 10 active reading tasks for both the SMART Note and baseline prototypes that required them to engage the active reading strategies previously outlined in the KLM study.**

evaluation. Participants had no prior experience with Inkling Habitat and either own or had experience with a tablet. Participants completed 10 tasks for both the SMART Note and baseline prototypes that required them to engage the active reading strategies previously outlined in the KLM study. Table 6.3 shows the complete list of active reading tasks used in both evaluations. To minimize learning effect, the order in which SMART Note and Inkling were presented was counterbalanced

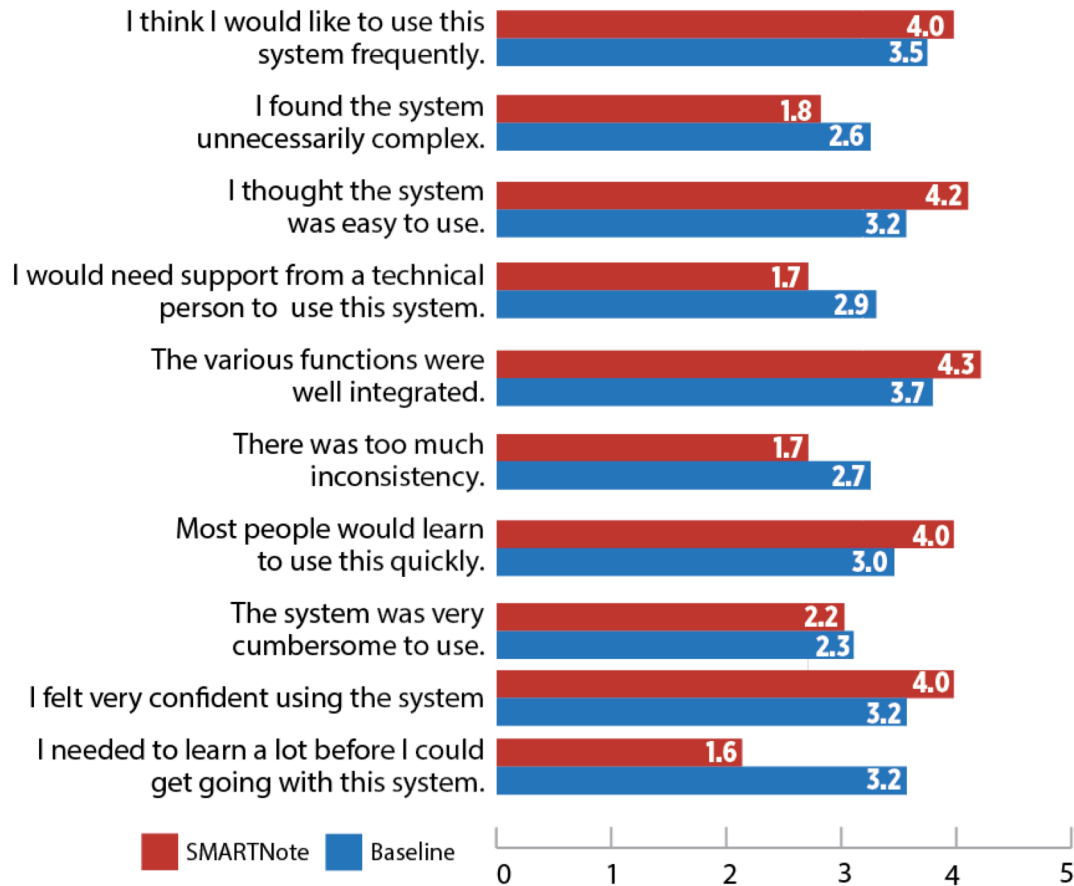
across participants. Participants rated the perceived difficulty of each task and participants responded to the Systems Usability Scale (SUS) for each prototype. Follow-up questions about usability and preferences rounded out the research.

Task	Task Instructions
1	Imagine you want to save a key term so you can review/study it later. How would you do that?
2	Imagine you want to highlight a sentence. How would you do that?
3	Imagine you want to add a note to the highlighted sentence. How would you do that?
4	Now turn to the second page of the chapter. Imagine you want to make notes over the video. How would you do that?
5	Imagine you want to make notes over the audio that accompanies the video. How would you do that?
6	Now, turn to the third page of the chapter. Imagine you want to make some notes over the interactive graphic you see there. How would you do that?
7	Now turn to the fourth page of the chapter. Imagine you would like to make some notes over the image slide show you see there. How would you do that?
8	Imagine now, you have completed reading the chapter and want to look at the annotations you made while you were reading. How would you do that?
9	Examine your notes and explain how you think this tool works.
10	Now you want to return to the body of the chapter. How would you do that?

**Table 6.3. For both the SMART Note and Baseline prototypes, each participant engaged in a 10-task usability session.**

### 6.2.2 Results

Overall, SMART Note scored slightly higher on the Systems Usability Scale (Figure 7.14). None of the SMART Note tasks scored above 2.2 difficulty rating (7-point Likert scale: 1=very easy, 7=very difficult). Likewise, all tasks yielded at least a 90% success rating. Two tasks scored above a 2.2 difficulty rating on the Baseline Prototype: (1) *save a key term and definition* (5.5 difficulty rating) and (2) *take notes over the audio that accompanies a video* (4.7 difficulty rating). The success rating for each of those tasks was also slightly lower, at 60%. All 10 participants reported they preferred the SMART Note design and features to the baseline prototype that represents most existing



**Figure 6.14. Average responses to the Systems Usability Scale (SUS) for SMART Note and Baseline prototypes**

active reading tools currently on the market. Five themes emerged during interviews, reported in the rest of this section.

#### *6.2.2.1 Leveraging properties of tablets for active reading*

Six participants [P2, P3, P4, P5, P6, P10] indicated that the SMART Note design better represented their needs in the tablet environment, while the baseline prototype seemed more concerned with replicating the traditional textbook active reading experience. According to one participant, “SMART Note seemed to represent a true change in the way people make notes on tablets” [P3]. Several participants also made direct reference to SMART Note’s divergence from print-centric active reading strategies. One participant said, “the SMART Note tools were central to the tablet study experience” [P6]. Another said “the [baseline prototype] was more traditional in terms of

how you use it to annotate. It seemed to be more based on what you do with a paper textbook, not a digital textbook. SMART Note seemed to be better thought out in terms of how people would annotate on a tablet” [P10].

#### *6.2.2.2 Encouraging annotation and careful study*

Five participants [P2, P3, P5, P7, P9] said they felt more inclined to annotate in SMART Note than in the baseline. “I would be motivated to take more notes, [which are] more exact without taking me out of the reading process. My notes seem more orderly and precise,” one said. Two [P3, P7] participants also cited increased interactivity as a motivating factor, and three [P2, P3, P9] indicated a greater number of media-specific annotation tools encouraged them to annotate more in the digital space. According to one participant, “SMART Note is a better product because there are more ways to use it and take notes. There were also more ways to tie notes directly to the content” [P3].” Four [P3, P5, P7, P9] reported that because annotation tools were easier to use, their desire to make notes increased.

#### *6.2.2.3 Minimizing interface interaction in the study flow*

All 10 participants reported SMART Note tools were less distracting and more efficient than baseline prototype tools. According to one participant, SMART Note made it “easier for me to complete the tasks. For example, with key terms, I could just tap a button to save. It was a lot easier for me to do that and keep reading. In the [baseline prototype], the fact that I had to stop and [manually enter a definition] distracted me. I got disoriented” [P1]. Moreover, five participants preferred one-tap highlighting to drag-and-swipe interaction. “I hate highlighting on touch screens because it’s so clunky,” [P1] noted. “When I am trying to read a lot of text, it’s really distracting from what I am reading. It takes so long to highlight when you have to drag your finger across the text. With SMART Note, I can just tap and keep reading. I don’t even have to think about it” [P1]. Eight participants also said although most of the baseline tools were functionally easy to use, they were more cumbersome in the context of active reading. “I was able to functionally use [the baseline prototype]. However, it took a lot of time to physically make the annotations. The tools weren’t really designed for multimedia” [P5]. Likewise,

[P4] said, the baseline prototype required more thought regarding how to effectively annotate because “the tools really didn’t support note taking well. I had to work harder to get the notes in the system” [P4]. All 10 participants also noticed that fewer touch interactions were required to make annotations: “The SMART Note version clearly required fewer taps....Lots of tapping, and moving, and swiping is really confusing and distracting” [P8].

#### *6.2.2.4 Watching to study: Enabling robust video annotation*

It is worth noting that four participants [P3, P5, P9, P10] asserted that they often find educational videos difficult to annotate and study. According to one, “videos are easy to watch but hard to study because you have to do so much rewinding and re-watching to really have it sink in. But the SMART Note tools helped me mark things—like definitions, or parts of the video—so that I didn’t have to pause so much” [P3]. Likewise, six said they appreciated the fact that SMART Note provided several different options for annotating video: “When I was using the [baseline prototype], I kept wanting to annotate differently for each type of media. I felt like annotating video should be different from annotating text. But it really wasn’t. Then, I used the SMART Note, and you could do those things. That made a lot more sense to me” [P6]. Additionally, fewer interruptions from watching video to annotate was popular among participants. “I don’t like being interrupted when watching videos,” one participant said. “So normally, when I have to watch a video for class, I just watch it. I don’t take many notes because it’s hard to stay focused on the video and take notes at the same time. But with SMART Note, you could actually take lots of notes—grab lots of key information—without even stopping” [P6].

#### *6.2.2.5 Self-organizing annotations as a study guide*

All 10 participants reported that SMART Note organized annotations more clearly in the concatenated notebook. Participants commonly said the SMART Note Concept Map Study Guide was “more precise”, “easier to understand”, or “better organized” than the baseline notebook in the baseline prototype. Visual cues [P4, P7, P8, P9, P10] and filtering annotations by media type [P1, P2, P3, P5, P6, P8] were popular. “It is important to keep notes related to content. In other words, the types of notes you’re taking are

irrelevant. It's the information that you're tying the notes to that is important. That's what will help you remember the information. So, I want to know, 'did I take this note over a video or text or a picture?' SMART Note ties that all together so I can immediately see it" [P3]. Another participant said, "It's like it guided me through. The more complex the subject matter or the longer the video, the more those tools really come in handy. It helped me figure out what I wanted to do and gave me a lot of really rich information easily" [P4]. One participant also said, "The design of the icons also appealed to me. It offered more visual cues and that's important to me because visuals help me remember" [P9].

### **6.2.3 Discussion**

Results from the modified KLM and user experience evaluations demonstrate that SMART Note improves active reading efficiency on several key active reading tasks, as well as provides learners with promising novel strategies for annotating multimedia in tablet textbooks. Based on these results, three key observations are relevant to the discussion of how the SMART Note conceptual design contributes to our understanding of tablet active reading.

#### **6.2.3.1 *Minimizing functional overhead during active reading***

It is important to understand the difference between interaction that contributes to meaningful learning and interaction that represents meaningless and sometimes distracting mechanical overhead. Certainly, the act of translating a text "into my own words" or manually copying important information into a notebook, outline, or study guide often contribute to a learner's ability to recall that information later. Thus, SMART Note is not intended to replace any strategy that would support that process. However, touch screen devices and multimedia content clearly require interaction mechanics that impede the flow of active reading. Superfluous tapping, swiping, pausing, rewinding, and other interaction mechanics quickly multiply, costing learners time and efficiency. These actions also create potentially detrimental distractions or disorientation. Thus, the SMART Note conceptual design shows promise as a means for mitigating mechanical interaction that fails to contribute to learning. Furthermore, the cumulative effect of



efficiency gains illuminated during the KLM evaluation will be significant when applied to a complete active reading session during which a learner applies numerous active reading strategies to many different types of content.

#### *6.2.3.2 Specificity of tablet textbooks for active reading*

New platforms (i.e., tablet texts) often replicate strategies found in traditional platforms (i.e., print texts); however, the core experience is often different. Thus, the question of what happens to our active reading goals, strategies, and needs when textbooks migrate from traditional print formats to touch-screen platforms is significant. The SMART Note conceptual design represents a contribution to this evolution by grounding its active reading support in the mechanics and affordances of the tablet environment, as opposed to attempting to parallel established print mechanics and affordances. This was evident in both evaluations, particularly when it comes to the significant time and interaction gains for one-tap highlighting, key term capture, and audiovisual annotation tools. As one user noted, “SMART Note was designed for the tablet textbook specifically, not the textbook concept generically” [P8].

#### *6.2.3.3 Organizing and architecting annotations*

Although the tablet environment provides new possibilities for automated organization of annotations, simply allowing learners to see their notes collected into a list separate from the body of the text may fall short of fulfilling their study requirements. When annotations are presented in a text-based list according to the order in which they were made, learners may struggle to remember their significance or original context. Additionally, without visual cues that indicate whether a note was taken in reference to text, video, or another media format, it may be difficult for learners to construct a mental model that effectively connects annotations to their original sources. Finally, there is evidence that suggests that the most effective active reading strategies are those in which learners construct meaningful artifacts, such as chapter outlines or flash cards. However, a concatenated list lacks this very useful information architecture. Thus, because SMART Note uses visual cues to remind learners about the origins of their annotations, allows

learners to filter annotations by media type, and provides both list and concept map views of annotations, the review process is potentially enhanced.

Granted, the analytical and user experience studies outlined in this chapter represent first-level, controlled evaluations of SMART Note that focus on assessing the fundamental properties of active reading support in terms of efficiency, usability, and perceived appropriateness for the learners. However, these studies are not yet sufficient for underscoring claims about whether SMART Note improves a learner's overall active reading experience during a natural study session. Thus, the following chapter chronicles a final study that compares SMART Note to the Baseline prototype on four performance measures: overall usability, perceived cognitive load, learner active reading experience, and general learning outcomes. The following chapter also introduces the Active Reading Experience Questionnaire (AREQ) and reports on a study conducted to validate it as an instrument for specifically measuring user active reading experience.

## **7 Developing and Validating A New Instrument for Evaluating Active Reading Experience**

Several well-established instruments exist for assessing the usability of a digital system. The Systems Usability Scale (SUS), for example, has become industry standard for measuring perceived usability, and research has shown that it can often be trusted as a global measure of system satisfaction and sub-scales of usability and learnability (Lewis & Sauro, 2009). Likewise the Questionnaire for User Interaction Satisfaction (QUIS) (Chin, Diehl, & Norman, 1988) and User Experience Questionnaire (UEQ) (Schrepp, Hinderks, & Thomaschewski, 2014) both provide varying degrees of insight into user satisfaction measures. However, these instruments are generically designed for studying usability and user experience with any interactive system, from an ATM machine to a website. Although they are effectively versatile, these standard instruments are not nearly robust enough to examine the active reading experience, which is governed by a very specific set of goals, strategies, and principles.

The Active Reading Experience Questionnaire (AREQ) is proposed to address these concerns. AREQ is a 29-item questionnaire that can be used in a number of settings to assess active reading. For example, it may be used to assess what types of active reading strategies students regularly employ or find most useful. Or it may ask learners to rate how well any active reading tool supports a wide range of active reading goals and strategies. As such, the AREQ could be used in combination with other standardized usability measures to generate a more complete picture of whether a novel system effectively supports users in all their active reading goals. Following are results of a three-part validation study of the AREQ instrument. In the first stage, the AREQ was drafted based on a review of the extant literature on active reading and learning. AREQ items focus on three main categories related to active reading: 1) technologies a learner might use during active reading (e.g., paper, computer, digital device), 2) a learner's purpose for active reading (e.g., to aid in memorization, summarization, synthesis of ideas), and 3) specific physical strategies a learner might engage in during active reading (e.g., annotation, outlining, cross-referencing). In the second stage, five independent reviewers with expertise in active reading engaged in a systematic analysis of a first draft of the AREQ to establish content validity. Then, the AREQ was revised based on expert

feedback. In the third stage, the revised AREQ was administered during a thought experiment with 50 undergraduate students to establish criterion validity and item-to-total reliability. The AREQ was again revised, resulting in the final validated instrument. This research contributes a new and fully validated tool for assessing active reading experiences by specifically focusing on primary active reading activities and goals. The questionnaire is intended for usability studies focused on examining how well an individual tool helps learners meet their active reading goals, as well as more generalized research focused on learners' active reading behavior. This study has been approved by IRB #IRB-570895-1.

### **7.1 Initial questionnaire development**

Most research on active reading alone has focused on specific strategies students or workers enact when reading educational or informational materials. Simply put, active reading refers to reading with determination to understand, evaluate, and retain information for its relevance to an individual's needs. Thus, all of the cognitive and physical strategies recommended in traditional and contemporary models of active reading informed the initial development of the AREQ.

Specifically, both relevant research on active reading and SQ3R strategies (detailed in Chapter 3) and five active reading resource sites ("Skills for OU study," 2013; "Active reading," 2014; Active reading comprehension," 2011; Active reading strategies," 2010; Active reading strategies," nd.) were reviewed to inform the initial development of the AREQ. A comprehensive list of all of the cognitive and physical strategies recommended by each site was developed. Then, recommendations common to two or more sites were combined and/or streamlined. Based on this review of literature and widely used active reading support tools and websites, a 24-item questionnaire was developed that included a comprehensive list of the most commonly recommended active reading activities, including both physical strategies (e.g., outlining and highlighting) and cognitive processes (e.g., synthesizing information and analyzing a text for accuracy). This first draft was then delivered to five expert reviewers charged with analyzing the first draft AREQ for clarity, cohesion, and completeness.

<b>STEP 1</b>	<b>Instructions:</b> Look for problems with any introductions, instructions, or explanations from the respondent's point of view.
<b>STEP 2</b>	<b>Clarity:</b> Identify problems related to communicating the intent or meaning of the question to the respondent.
<b>STEP 3</b>	<b>Assumptions:</b> Determine if there are problems with assumptions made or the underlying logic.
<b>STEP 4</b>	<b>Knowledge/Memory:</b> Check whether respondents are likely to not know or have trouble remembering information.
<b>STEP 5</b>	<b>Sensitivity/Bias:</b> Assess questions for sensitive nature or wording, and for bias.
<b>STEP 6</b>	<b>Response Categories:</b> Assess the adequacy of the range of responses to be recorded.
<b>STEP 7</b>	<b>Other:</b> Look for problems not identified in Steps 1 - 7.

**Table 7.1: The steps of the QAS process used in this study involve seven units of analysis (Willis & Lessler, 1999).**

## **7.2 Content validity: Expert review**

### **7.2.1 Participants**

Four of five expert reviewers are university learning center employees at three different institutions. Two are tutoring coordinators at a midsized Midwestern university and specialize in reading, writing, and language success strategies. The third is the executive director of academic support programs at a large Midwestern university. The fourth is an academic skills center director at an Ivy League research university. The fifth reviewer is a cognitive psychology professor at a midsized Midwestern university. The reviewers were selected because they had similar expertise in active reading and learning, as well as experience in working with students to improve core study skills. The experts were selected to minimize variation in background characteristics across the experts, rather than attempting to draw a probability sample of all experts. To maintain independence, all reviewers were asked to conduct the reviews individually.

### **7.2.2 Procedure**

Expert reviewers completed the Questionnaire Appraisal System (QAS-99) (Willis & Lessler, 1999) to evaluate survey questions. The QAS-99 classifies the cognitive processes inherent in the question-answering process (Lessler & Forsyth, 1996) and guides expert reviewers through a systematic appraisal of each question. Categories

center on assessment of overall instructions, clarity of questions, assumptions in logic, respondents knowledge or memory, sensitivity or bias, and response categories, with an open-ended assessment question at the end. Table 7.1 provides a brief description of each QAS step. The QAS-99 helped reviewers spot potential problems in the wording or structure of questions that could result in difficulties in question administration, miscommunication, or other failings. Using QAS-99 as a guide, the expert reviewers examined the initial set of proposed questions by considering specific categories of question characteristics in a step-by-step fashion. At each step, expert reviewers decided whether each question exhibited features that were likely to cause problems. In completing the appraisal, expert reviewers indicated whether a problem was present by circling *yes* or *no* on an accompanying coding form. The complete coding form can be found in Appendix D. For each *yes* circled, reviewers were asked to note the reason and provide a recommended solution. Reviewers were also asked to comment on the AREQ's completeness and recommend additional items if necessary.

### **7.2.3 Results**

Collectively, reviewers identified 17 unique issues with the first draft of the AREQ that could potentially be problematic. Four issues were related to the clarity, accuracy, or perceived complexity of the instructions, introductions, or explanations. For example, the first draft included reference to “media format” as a means for generalizing the notion that educational content could be delivered in many ways, from text, to audio, to video. That language was subsequently removed from the final draft to minimize confusion. Twelve potentially problematic issues were related to the clearness of the meaning or intent of the AREQ items, with six revolving around items that could result in multiple interpretations. For example, one reviewer noted that there was little difference between an item that made reference to “taking notes on another digital device (e.g., laptop, smartphone, tablet)” and another that made reference to “taking notes within the tablet environment.” Likewise, another reviewer noted that an item that made reference to “evaluating a text” was too similar to one that focused on “analyzing a text for accuracy.” In this case, the former was eliminated based on the notion that the latter was both clearer and more comprehensive. Three reviewers also noted that use of the phrase “synthesize

<b>Active Reading Experience Questionnaire Items</b>
Please indicate your level of agreement with how well this tool supported you in the following active reading goals (7 strongly agree, 6 agree, 5 somewhat agree, 4 neutral, 3 somewhat disagree, 2 disagree, 1 strongly disagree)
<b>Technology</b>
Item 1. Take general notes on paper or in the margins (not a structured outline)
Item 2. Take notes on a digital device (i.e., laptop, smartphone, tablet)
Item 3. Mark parts of a video (i.e., make note of a specific point in the video timeline so you can add a note to it or easily find that point in the video later)
Item 4. Save portions of a video
Item 5. Take notes over video content
Item 6. Record audio notes
<b>Purpose</b>
Item 7. Comprehend what I read or watch (for example, be able to answer questions about it and discuss topics in my own words)
Item 8. Memorize parts of the educational material
Item 9. Search for a specific piece of information
Item 10. Analyze the educational material for accuracy
Item 11. Evaluate educational material to form my own opinion
Item 12. Synthesize what I read or watched (i.e., combine information to see how it all fits together)
Item 13. Understand the author's purpose
Item 14. Understand the structure of the educational material
Item 15. Understand the author's stance
<b>Physical strategies</b>
Item 16. Highlight text
Item 17. Make notes of key terms
Item 18. Organize annotations (i.e., notes) into a different format
Item 19. Test myself over the information
Item 20. Rank my annotations (i.e., notes) in order of importance
Item 21. Summarize educational material in my own words
Item 22. Mark main ideas
Item 23. Create a practice test
Item 24. Make an outline of the material
Item 25. Make a flow chart of the material
Item 26. Make note cards
Item 27. Survey each chapter by reading the introductory and concluding paragraphs, headings, subheadings, visual captions, review questions, etc.
Item 28. Make study questions
Item 29. Cross-reference information from lecture notes and information from the assigned educational materials
Item 30. Orally recite what I've read or watched after each section/main topic

**Table 7.2: The final AREQ is comprised of 30 items divided into three main categories: technologies used during active reading, purposes for active reading, and physical strategies employed during active reading.**

what I read” might confuse students who don’t fully understand what it means to synthesize content consumed from an educational text. Thus, a parenthetical example – (e.g., combine information to see how it all fits together)” – was added to clarify the term. Finally, one double-barreled item – “understanding the structure & purpose of the text” was identified and was divided into two separate items.

Each unique concern raised by reviewers was addressed through revision, rewording, and/or restructuring, which resulted in a revised 30-item AREQ with items organized into three topical categories: 1) technologies used during active reading, 2) purposes for active reading, and 3) physical strategies used during active reading (Table 7.2 shows all AREQ items as they were presented during the thought experiment). It is worth noting that two reviewers expressed concern that the Likert scale – strongly agree, agree, somewhat agree, neutral, somewhat disagree, disagree, and strongly disagree – was inadequate and/or potentially confusing. However, the decision to use this scale was based on recommendations for Likert item scales of agreement (Ray, 1951; Wakita, Ueshima, & Noguchi, 2012). Thus, no change was made in the Likert scale from the first to the second draft of the AREQ.

### **7.3 Reliability and criterion validity: Thought experiment**

To establish both reliability of individual items and criterion validity, a thought experiment (Mach & Hiebert, 1976) was conducted to explore the extent to which the AREQ discriminates among common real-world reading scenarios. The first scenario describes a critical active reading experience in which a student is very motivated to learn from a specific collection of educational materials and has little prior experience with the content. The second scenario is described as a minor active reading experience in which a learner is less motivated to engage in active reading. Students’ responses to AREQ items were expected to be different for these two scenarios.

#### **7.3.1 Participants and procedure**

Fifty undergraduate student participants were recruited through the university’s research subject pool administered through the Department of Psychological Science. In exchange for their participation in an online thought experiment via Survey Monkey,



students were given research participation credit in an introductory Psychology course. After a brief introduction and informed consent, participants were given two different prompts. In the first, they were asked to:

*Imagine an educational learning experience in which you must study a chapter of a textbook and two related videos that you will be tested over. Imagine also that you are very motivated to learn the material and retain it for a long time. Finally, assume that you have little to no prior experience with the educational concepts you are studying.*

Participants were then asked to complete the AREQ with this scenario in mind. Next, they were given a second prompt:

*Now, imagine an educational learning experience that involved a very easy course in which you feel very knowledgeable about the content and know you can pass the tests fairly easily. Again, the test will be based on a chapter of a textbook and two related videos.*

Again, participants were asked to complete the AREQ with the new scenario in mind.

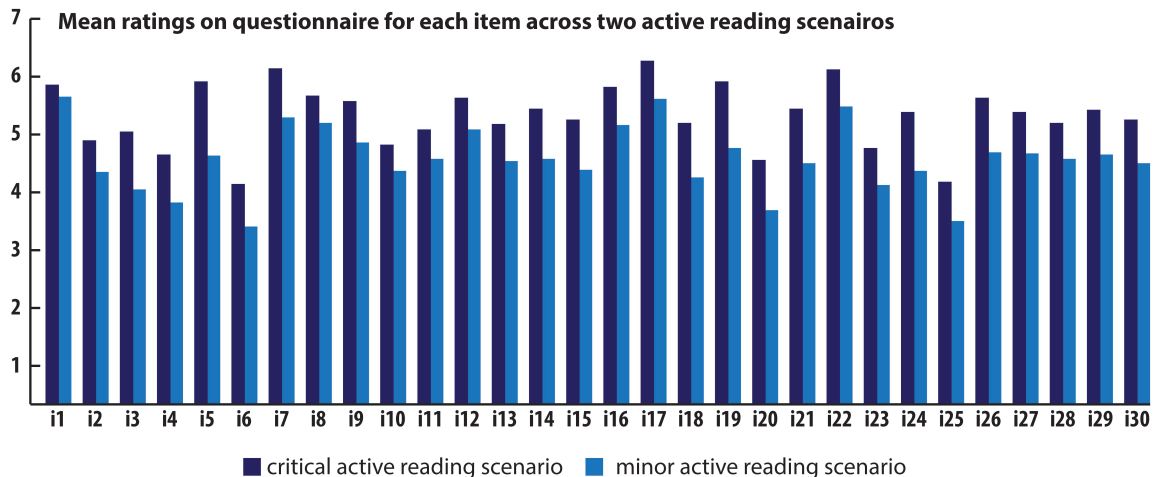
### **7.3.2 Reliability**

Analysis indicates that the questionnaire is a reliable scale. For each student for each scenario, a total score was calculated by adding all 30 items. Using SPSS, Pearson correlation coefficients were calculated between the student's score on each item and the total. The mean correlation was .60. Significance tests using an experiment-wise alpha of .0017 ( $\alpha .05/30 = .0017$ ) indicated that all 30 correlations were positive and significant. However, two items had moderately low correlations (item 2  $r = .35$ , item 8  $r = .34$ ). Factor analysis was not attempted since there were too few participants for a reliable analysis.

### **7.3.3 Criterion validity**

Analysis indicates that the scale has reasonable criterion validity. Two analyses support this. First, a t-test was calculated on total scores to compare scenario 1 with scenario 2. The mean for the critical active reading scenario was 159 and the mean for the minor active reading scenario was 135. This difference is significant ( $t(49) = 7.75$ ,  $p < .001$ ).

Next, a fully factored ANOVA with scenario (2 levels within) and items (30 levels within) was calculated. Scenario was a significant effect and accounted for a substantial percent of the variance ( $F(1, 49) = 60.00, p < .001, \eta^2 = 8\%$ ). Questionnaire items was a significant effect and accounted for a substantial percent of the variance ( $F(29, 1421) = 15.41, p < .001, \eta^2 = 16\%$ ). The interaction between scenario and items was significant ( $F(29, 1421) = 1.96, p < .01, \eta^2 = .6\%$ ), however, the interaction did not even account for one percent of the variance, suggesting that the interaction is not meaningful. Bonferroni t-tests ( $\alpha = .0017$ ) were calculated for each item, comparing the mean for scenario 1 with the mean for scenario 2. The t-tests were significant for items 2 to 30, but not item 1 ( $t(49) = 1.19, ns$ ). Item 1 (“take general notes on paper or in the margins”) was something that students agreed they did in both scenarios (mean for critical active scenario = 5.86 and mean for minor active scenario = 5.64).



**Figure 7.1. The critical active reading scenario had higher means than the minor active reading scenario for all items. In all but one (i1), the difference was significant.**

#### 7.4 Instrument application and future use

The study reported here successfully establishes both content and criterion validity for the AREQ, making it a valid and useful instrument for assessment of active reading experience. Only one item on the revised AREQ – “take general notes on paper or in the margins” – did not yield statistically significant differences between the two active reading scenarios. Therefore, this item was removed from the final AREQ (see

Appendix E to view the final AREQ). One reasonable explanation for this is that students are, indeed, likely to at least take general notes over any reading materials they know they will be tested over, regardless of the scenario. In other words, even when they feel they know the material relatively well, at a bare minimum, students will jot down a few notes as they read. Thus, it is unlikely that a student's response to this item would provide much insight into whether a particular tool actually helps students meet significant active reading goals. However, significantly different means for the other 29 items indicate that the relative importance students place on individual active reading activities varies according to how carefully they feel they need to study the material. Equally important is the fact that average ratings for each AREQ item were above neutral for all but two items – “record audio notes” and “make a flow chart of the chapter.” This indicates that participants generally agree that 28 of 30 AREQ items presented during the thought experiment are a strong representation of the strategies they believe are important to a successful active reading experience. Had the sample included a large number of music majors or engineers, the audio and flow chart items may have also been rated above neutral.

Future research may take advantage of the AREQ in a number of ways. In general, the AREQ is designed to explore whether a particular set of active reading tools effectively supports a learner's ability to apply best practices in active reading. Thus, one specific scenario involves the assessment of novel prototypes for digital active reading. The following section provides further detail regarding how SMART Note was used in a comparative study that measures the effectiveness of existing active reading tools in tablet textbooks to SMART Note. In addition to standard usability scales and learning outcome measures, the AREQ helps paint a more complete picture of how well SMART Note supports active reading. Thus, the AREQ could be similarly useful to all researchers who explore novel systems to support active reading in the digital realm.

A second scenario of use for the AREQ involves assessment of a specific active reading experience or setting. Because AREQ items are based on the activities and strategies most experts agree represent best practices in active reading, the questionnaire may also be used to explore the extent to which students actually employ those strategies in their regular educational reading pursuits. For example, individual teachers could use

AREQ to form a better understanding of the active reading strategies their students regularly employ. In this sense, a researcher could use the AREQ study whether there are reliable differences between students earning particular grades in a class (e.g., A versus C) and use of particular active reading strategies with course materials. Future research might also examine different active reading preferences among different subject majors. For example, students majoring in Sciences might regularly engage in different active reading habits than students majoring in Humanities, and both might differ from applied disciplines, such as engineering or architecture. Likewise, a researcher could study changes in active reading styles between different populations of students (e.g., freshmen versus seniors). Finally, research could explore how cognitive or personality characteristics affect active reading styles (e.g., differences between those with high visualization skills and low visualization skills). In all of these examples, the AREQ shows promise for exploring a general population of students' self-reported active reading strategies in a number of relevant scenarios. This is significant because it could help identify which potentially useful active reading strategies students are less familiar with and provide guidance for educators regarding where to focus active reading instructional efforts.

In summary, active reading is governed by a very specific set of goals, strategies, and principles. Thus, when it comes to testing the effectiveness of novel active reading-study systems or exploring students' general active reading habits, standard usability scales and learning outcomes research fall short of assessing the complete active reading experience. The proposed Active Reading Experience Questionnaire was, therefore, designed to enhance active reading research by providing an instrument for prompting learners to report on their active reading strategies for a specific active reading experience. Ultimately, the AREQ may help researchers more effectively matching future active reading support tools to learners' active reading goals and needs. Chapter 8 chronicles a comprehensive study that combined the AREQ with other usability, user experience, and learning outcome measures to compare the SMART Note system to active reading support offered by existing systems.

## **8 Comparative Assessment of Active Reading in a Natural Setting**

### **8.1 Rationale and goals**

The preceding studies suggest that SMART Note active reading features and strategies show promise for improving both learner experience and learning outcomes. However, none have explored these ideas in the context of an actual study session. The purpose of the experiment that follows was to understand how SMART Note compares to active reading support provided by existing tablet textbooks (specifically those offered by Inkling Habitat) in the context of a natural study session.

Participants studied a chapter of educational material delivered in one of two fully functional tablet textbook prototypes. The first was SMART Note and the second was a Baseline prototype that was designed to emulate all of the annotation and notebook features of Inkling Habitat, the leading tablet textbook platform currently on the market. The SMART Note web app can be accessed at <http://smartnoteproject.com/smart/> and the Baseline web app can be accessed at <http://smartnoteproject.com/inkling/> on any device or computer. However, for optimum functionality, view them on any Retina iPad device. Participants were then quizzed over the material to compare learning outcomes. Questionnaires that measured perceived cognitive load, active reading experience, system usability, and perceived usefulness of active reading strategies provided by each prototype were also administered. Finally, comments concerning the value of each system were collected in semi-structured interviews to help paint a picture of the user experience. This research was conducted to answer the following research questions:

**RQ1:** How does SMART Note compare to a Baseline prototype on learning experience?

**RQ2:** How does SMART Note compare to a Baseline prototype on learning process?

**RQ3:** How does SMART Note compare to a Baseline prototype on learning outcomes?

This experiment has been approved by IRB #IRB-654252-2.

### **8.2 Hypotheses**

Fundamental learning strategies identified in prior characterizations of active reading drive the hypotheses laid out for this study. Specifically, this experiment explores

how the SMART Note and Baseline systems support the physical strategies learners commonly use during active reading (i.e., annotation, reorganization, browsing, and cross-referencing), as well as the responsive processes involved in the act of studying (i.e., progressing without interruption, searching for and acquiring desired information, and getting an overview about the general structure of the material). Thus for the purpose of organizing the active reading experience, the study design can be characterized in three parts: learning experience, learning process, and learning outcomes. Based on this categorization, the following hypotheses guided this experiment.

### **8.2.1 *Learning experience***

**H1:** SMART Note will better support learners in engaging in the physical active reading strategies than Baseline strategies and tools.

The SMART Note design was conceptualized to equally support active reading of multiple types of content (i.e., text, video, audio, etc.) in the tablet environment. Thus, the SMART Note tools are designed to support individual learners more precisely and thoroughly than the Baseline prototype, which has fewer annotation tools, filtering capabilities, and organizational methods. The Active Reading Experience Questionnaire (AREQ) will be used to assess this hypothesis.

**H2:** SMART Note will be rated easier to use than the Baseline prototype.

This hypothesis is based on the fact that SMART Note provides more precise active reading features and tools, as well as a greater number of annotation features than the Baseline prototype. Thus, users will find annotation and study tasks easier in SMART Note because the functionality of the system is easier to engage and understand. Additionally, SMART Note provides learners with annotation strategies and features that require less mechanical interaction with the device. Thus, potential distractions from learning will be minimized and the active reading process will be more efficient. Three different kinds of analysis were used to examine this hypothesis: the Systems Usability Scale (SUS) measured overall usability, The National Aeronautics and Space Administration – Task Load Index (NASA-TLX) measured perceived cognitive load, and a feature-level utility rating questionnaire designed specifically for this study gauged participants' perceptions of individual annotation tools provided by each system.

### **8.2.2 *Learning process***

**H3:** SMART Note users will spend significantly more time engaged in active reading (i.e., reading, annotating, and reviewing content) than Baseline users.

SMART Note offers a greater variety of annotation features, which may provide learners with more opportunities to interact with a text. Furthermore, SMART Note provides learners with more ways to filter and organize annotations than the Baseline prototype, which may also result in increased interaction and engagement with annotations once they are made.

**H4:** SMART Note users will make more annotations than those who use the Baseline strategies and tools.

This hypothesis is based on the fact that SMART Note offers a greater variety of annotation features, which may provide learners with more opportunities to make a robust and useful set of annotations over the material.

### **8.2.3 *Learning outcomes***

**H5:** Quiz scores – both short answer and key term matching – will be higher for SMART Note users than Baseline users. This hypothesis is dependent upon the preceding hypotheses because it is based on the idea that as user experience and learning process improve, so too should learning outcomes. Positive correlations between user experience/learning process outcomes and quiz scores are also expected.

## **8.3 Study Design**

### **8.3.1 *Participants and procedures***

Eighty-four undergraduate students (aged 18-23; 23 male and 61 female) participated in this study and were recruited through two methods. First, all undergraduate students enrolled in Psychology 100 at Ball State University (approximately 1,200 students total) were alerted to the study through the Department of Psychological Science Research Participation website. All Psych 100 students are required to serve as participants in a total of 4.5 hours of research during the course of one semester or engage in alternative activities that provide some experience with

<b>Description of Activity</b>	<b>Approx. Time (mins.)</b>
<b>Introduction</b> Participants were given an overview of the study purpose and procedures and completed consent forms and active reading and demographic surveys. Participants were also given a brief training session on the active reading tools provided by the Baseline or SMART Note system.	<b>10</b>
<b>Study Session</b> Participants were asked to study the chapter on photosynthesis as they typically would for a class reading assignment, using the active reading tools provided by the tablet textbook platform.	<b>20-40</b>
<b>NASA-TLX</b> After reading and annotating the chapter, participants were asked to complete the NASA-TLX, taking into consideration how mentally demanding they perceived the “reading and annotation task” (not the difficulty of the material itself).	<b>3-5</b>
<b>Break</b> Participants were given a break intended to mitigate fatigue and establish separation between the “study session” and the “review session.”	<b>10</b>
<b>Review Session</b> Participants were asked to review the chapter and their annotations as they typically would in preparation for a quiz.	<b>15-30</b>
<b>NASA-TLX</b> After reviewing and studying the chapter, participants were again asked to complete the NASA-TLX, taking into consideration how mentally demanding they perceived the “reviewing and studying” task (not the difficulty of the material itself).	<b>3-5</b>
<b>Quiz over studied material</b> A quiz that included six short answer questions and 10 key term matching questions was administered.	<b>15-20</b>
<b>Experience questionnaires</b> Participants were asked to complete three brief questionnaires intended to gauge perceived usability (SUS), active reading experience (AREQ), and usefulness of individual active reading features.	<b>5-10</b>
<b>Semi-Structured Interview (audio recorded)</b> Interviews included pre-established and follow up questions to elicit feedback about the experience.	<b>5</b>

**Table 8.1. Participants attended a two-hour research session, during which they met one-on-one with the researcher.**

psychological research. In exchange for their participation in this study, students received two hours of research credit. Additionally, the principal investigator for this study visited sections of Journalism 101 (comprised of approximately 120 students) to give a brief



presentation and to invite students to participate. They were offered 30 extra credit points for their participation. Interested students were asked to provide their names and contact information so that a research session could be scheduled. Journalism 101 students who did not wish to participate in this experiment were allowed to complete an alternative equivalent assignment to earn 30 extra credit points.

Participants were randomly divided into one of two groups: the “Baseline condition” (n=42; 29 female, 13 male) or the “SMART Note condition” (n=42; 32 female, 10 male). The Baseline prototype was designed to emulate active reading features and tools provided by Inkling Habitat, the leading tablet textbook platform currently on the market. The SMART Note prototype includes novel active reading tools outlined in Chapter 5. Table 8.1 details study procedures, which were intended to instantiate the condition of a typical study session. A researcher was present to administer the protocol, observe the active reading session, and answer questions or tend to any technological difficulties a participant may have had during the session. The study began with an initial training session, during which participants were shown how to use the annotation tools provided by the system. Then, participants were given time to study and annotate (later referred to as the “annotation task”) the material, followed by a short break. Then, they were given time to review (later referred to as the “study task”) the material and any annotations they developed during the initial annotation session. A quiz was administered afterward to assess how well participants were able to remember select information from the Photosynthesis chapter. After the quiz was complete, three questionnaires (AREQ, SUS, and feature-level useful questionnaire) were administered to explore different aspects of the active reading experience. The aforementioned semi-structured interview rounded out the research.

### **8.3.2 Independent variables**

#### **8.3.2.1 User experience measures**

User experience was examined on three dimensions: 1) perceived cognitive load, as measured by The National Aeronautics and Space Administration – Task Load Index (NASA-TLX); 2) active reading experience, as measured by the Active Reading Experience Questionnaire (AREQ); and system usability, as measured by the System

Usability Scale (SUS) and a feature-level utility rating questionnaire designed to capture user perceptions about the individual active reading features provided by each of the tablet textbook platforms engaged for this study.

**The NASA-TLX** (Hart & Staveland, 1988) is one of the most widely used instruments to assess overall subjective workload. Participants rate their perceptions of six different dimensions – mental demand, physical demand, temporal demand, performance, effort, and frustration level – from low to high on 20-step bipolar scales, resulting in a score between zero and 100 for each dimension (see Appendix F to view complete NASA-TLX instrument). The underlying assumption of the instrument is that the combination of these six dimensions is likely to represent “workload” experienced by operators (Hart, 2006). Total scores for each of the six dimensions are then averaged to generate a “Raw TLX”, which represents overall workload. Originally, a weighting procedure was applied to the raw test scores to develop a composite score tailored to *individual* workload definitions, but many researchers have eliminated the weighting procedure and instead use the raw test scores. The Raw TLX instrument is simpler to apply. The ratings are averaged or added to create an estimate of overall workload (Hart, 2006). For this study, NASA-TLX was administered twice: once after participants completed the annotation task and once after participants completed the study task. The first time, participants were instructed to respond to each of the six questions in light of their thoughts about the note taking experience. The second time, they were instructed to respond to each of the six questions in light of their thoughts about the study experience. In both cases, participants were instructed to only consider NASA-TLX questions in light of the active reading tools they used, not the content of the educational material itself.

**The AREQ**, developed and validated specifically for this study, was used to assess how well learners felt the SMART Note or Baseline system supported a number of common active reading goals and strategies. The AREQ includes statements categorized on three dimensions: technology, purpose, and physical strategies.

The technology dimension includes six statements related to the operation of active reading strategies, such as “take general notes on a digital device” and “mark parts of a video (i.e., make note of a specific point in the video timeline).” The purpose dimension includes nine statements related to specific active reading goals, such as

“synthesize what I read or watched (i.e., combine information to see how it all fits together)” and “understand the structure of the educational material.” Finally, the physical strategies dimension includes 15 statements related to common active reading methods, such as “highlight text”, “organize annotations”, and “make notes of key terms” (see Appendix E to view complete AREQ instrument). Responses to individual statements for each dimension were totaled to achieve a score for each category. The maximum possible score for each dimension varies according to the number of items in each dimension on a seven-point Likert Scale (technology=42, purpose=63, physical strategies=105). Category scores were also summed to achieve a total active reading experience score for each participant (maximum possible total AREQ score=210).

**The SUS** (Brooke, 1996) was administered to assess participants’ opinions about the overall usability of the SMART Note or Baseline system. Based on prior research, a SUS score above a 68 is considered above average and anything below 68 is below average (see Appendix G to view complete SUS instrument).

**Finally, two feature-level utility rating questionnaires** (one for SMART Note and one for Baseline) were designed specifically for this study to further assess participants’ perceptions of how useful, easy to use, and how frequently they would use the active reading features provided by each system. It is important to note that each system offers different features. For the Baseline system, these included tap-and-drag highlighting, key term pop ups, video annotation, general note taking, page bookmarking, and the annotation notebook. For the SMART Note system, these included one-tap highlighting, key term capture, video key term capture, video transcript annotation, video point annotation, video segment capture, image capture and annotation, general note taking, and the concept map study guide (i.e., annotation notebook) (see Appendix H to view both feature-level utility rating questionnaires).

#### *8.3.2.2 Learning process measures*

Three dimensions of the learning process were identified for this study: 1) engagement during the annotation and study sessions, as measured by time on task, 2) robustness of annotations, as measured by the variety and number of annotations made

during the initial annotation session, and 3) review method, as measured by the ways in which participants engaged with their annotations during the study session.

**Time on task** was recorded for each step in the research protocol to measure how long participants engaged in each of the two key tasks, annotating and studying.

**The number and type of annotations** each participant made were stored in a backend database so that active reading activities while reading (as supported by each system) could be clearly counted and characterized.

### 8.3.2.3 *Learning outcome measures*

Quizzes administered after the study session provided a basic mechanism for assessing learning outcomes. Quizzes were the same in both conditions, as each prototype included the same chapter on Photosynthesis.

**Six short answer questions**, which emulated typical review questions in a 100-level Biology text, comprised the first part of the quiz. Participants were instructed to answer all six questions to the best of their ability, understanding that three or four sentences for each question would suffice. Two different independent subject matter experts (both Ph.D. students in the Department of Biology at Ball State University) scored all 84 quizzes to provide objective judgment of the quality of participants' answers. Table 8.2 outlines the four-point rubric scorers were asked to use.

Points	Description
3	Complete answer, with no significant errors that is deserving of full credit
2	Partial answer that is close to complete with a few minor details missing and/or minor areas of vagueness
1	Partial answer that contains a few accurate details, but lacking in one or more major details and/or major areas of vagueness to an answer; may also contain substantial intrusions that should not be present and/or off target responses
0	No answer, or completely incorrect answer

**Table 8.2. Scoring rubric for short answer quiz questions**

**Ten key term matching** questions were also included to gauge how well students could remember some of the more technical terms associated with the subject matter. Each term was worth one point, providing students the opportunity to earn a score of zero to 10 for this portion of the quiz (see Appendix I to view the complete quiz).

#### 8.3.2.4 *Qualitative measures*

**Semi-structured interviews** rounded out the data collection and included pre-established and follow-up questions to elicit feedback about the experience. Interview questions revolved around participants' perceptions of the overall tablet textbook experience and the individual active reading features, such as annotating, highlighting, and interacting with video and the annotation notebook. Interviews were analyzed using a coding scheme that was designed to illuminate key comments and ideas, as well as similar statements made by multiple participants (see Appendix J to view semi-structured interview questions).

**Observational notes** were recorded during each session, which included comments about the nature of participants' reading, annotation, and study patterns. Specifically, observational notes included any errors or confusion they may have experienced, technical difficulties, and questions asked or comments participants made during the session.

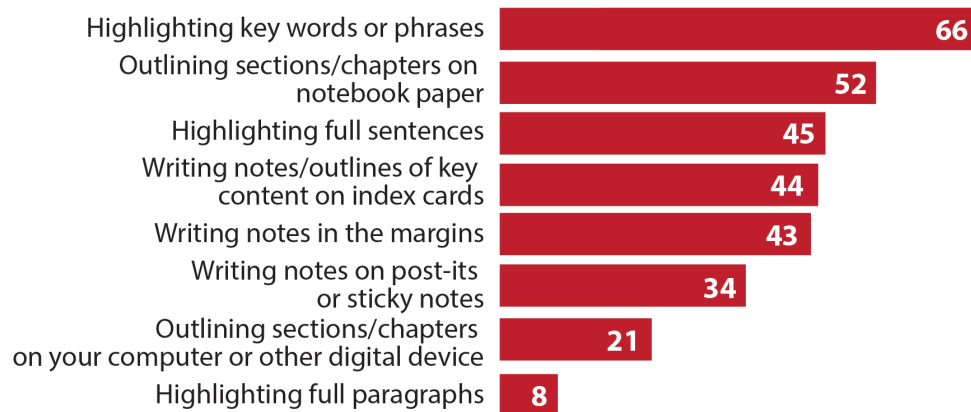
#### 8.3.3 *Dependent variables*

Both the SMART Note and Baseline prototypes were developed as web apps using HTML5 and CSS for the Retina iPad device and included the photosynthesis content that replicated content in a 100-level Biology text. As previously noted, the Baseline prototype was designed to emulate active reading features and tools provided by Inkling Habitat, the leading tablet textbook platform currently on the market. The chapter included text (approximately 2,500 words), videos and animations (one, two-minute animation and one six-minute video), and two interactive graphics.

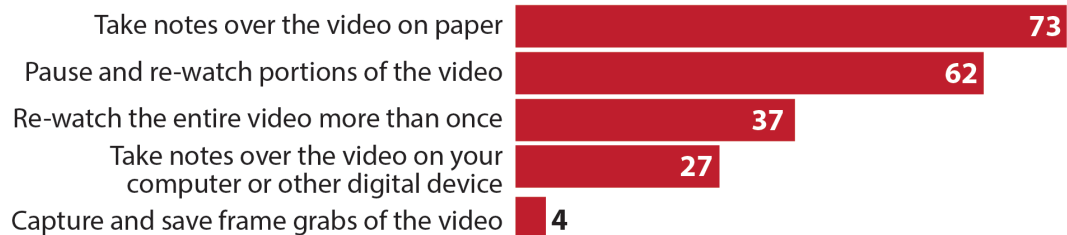
### 8.4 **Results**

After all data was entered into SPSS for analysis, it was carefully checked for accuracy and outliers. There weren't many outliers; however, there were a few, namely in the short answer quiz scores. In those cases, outliers were removed. In all other cases, the total number of participants equaled 84, 42 in each of the two conditions.

### Which strategies do you regularly use when you read textbooks?



### If given a video to watch and study, which of the following strategies would you use?



**Figure 8.1. Participants' self-reported active reading habits**

#### 8.4.1 *Demographics*

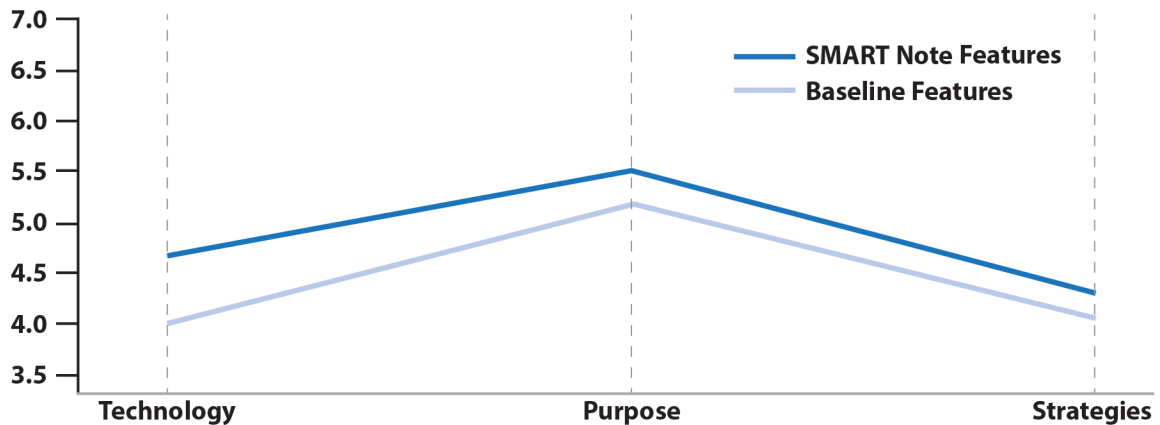
All 84 final participants reported low-moderate prior experience with the textbook topic photosynthesis. Twenty-eight of them reported prior experience with a tablet textbook, and 47 said they currently own or have owned a tablet device. Figure 8.1 shows the active reading strategies participants reported they regularly use to study educational textbooks.

#### 8.4.2 *User experience findings*

Independent-samples t-tests were conducted to compare active reading experience on several self-reported dimensions between the SMART Note and Baseline conditions: perceived cognitive load/overall workload as measured by the NASA-TLX (see Appendix F), active reading experience as measured by the AREQ (see Appendix E), system usability as measured by the SUS (see Appendix G), and feature-level utility, as measured by a three-part questionnaire designed specifically for this study (see Appendix H). Data are mean  $\pm$  standard deviation unless otherwise stated.

#### 8.4.2.1 Active reading experience as measured by the AREQ

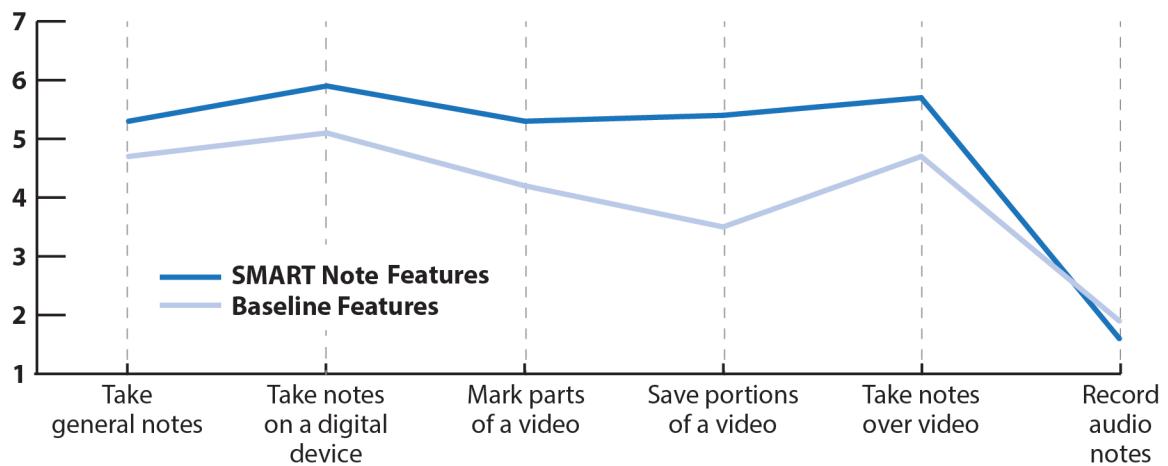
**SMART Note participants rated the active reading experience as significantly better than Baseline participants for three dimensions: technology, purpose, and physical strategies.** Because each dimension was represented by a different number of items on the AREQ (technology = six items; purpose = nine items; strategies = 15 items) original scores were divided by the number of items in the subscale to create average scores per subscale. Then, an ANOVA with one within variable (subscale with three conditions: technology, purpose, and physical strategies) and one between variable (condition with two levels, SMART Note and Baseline) was calculated to examine the active reading experience ratings.



**Figure 8.2. SMART Note was rated higher on all three dimensions of active reading experience.**

Overall, there was a significant difference between SMART Note and Baseline ( $F(1, 82) = 10.99, p = .001$ ). As shown in Figure 8.2, SMART Note was rated higher on all three dimensions of active reading experience. There was also a significant difference among the three dimensions ( $F(1, 82) = 50.49, p < .001$ ), with both SMART Note and Baseline rating about one point higher on the purpose dimension than the technology and physical strategies dimensions. There was not a significant interaction between condition and active reading experience dimension ( $F(1, 82) = 2.89$  ns). These results suggest that the SMART Note design provides a significantly better active reading experience than the Baseline prototype and similar tablet textbook platforms currently on the market.

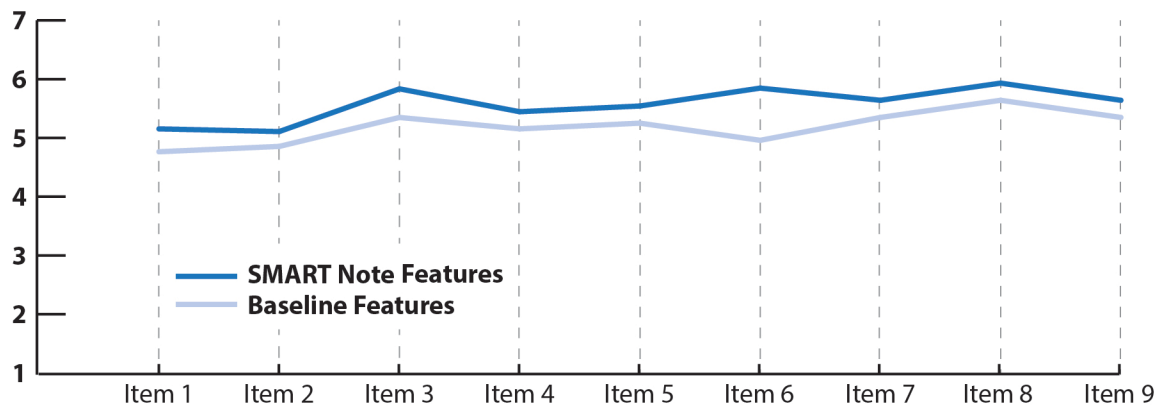
To further explore the individual items that contributed to these findings, separate ANOVAs were calculated for items in each of the three dimensions. The technology dimension included one within variable (subscale with six items) and one between variable (condition with two levels, SMART Note and Baseline). The purpose dimension included one within variable (subscale with nine items) and one between variable (condition with two levels, SMART Note and Baseline). And the physical strategies dimension included one within variable (subscale with 15 items) and one between variable (condition with two levels, SMART Note and Baseline).



**Figure 8.3. SMART Note was rated significantly higher on the technology dimension for all but one item, record audio notes. Differences among items were also significant.**

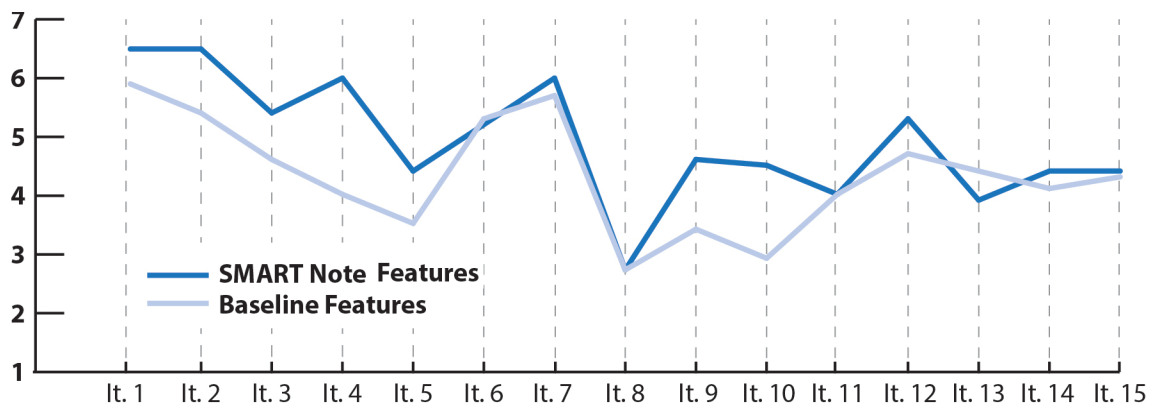
On the technology dimension, there was a significant difference between SMART Note and Baseline ( $F(1, 82) = 17.17, p < .001$ ). There was also a significant difference among the six items ( $F(1, 82) = 86.22, p < .001$ ) and a significant interaction did exist between condition and items in the technology dimension ( $F(1, 82) = 6.12, p < .001$ ). As shown in Figure 8.3, SMART Note mean ratings were not higher than Baseline for all items. Thus, Tukey t-tests were calculated to compare SMART Note to Baseline on each of the six items. There was a significant difference between SMART Note and Baseline on all six items,  $p < .001$ . Baseline rated higher on item six, which dealt with how well the system supported learners in making audio notes over the material, a feature not offered by either system. SMART Note was rated higher for the other five items.





**Figure 8.4. SMART Note was rated significantly higher on the purpose dimension for all nine items. Differences among items were also significant.**

On the purpose dimension, there was a significant difference between SMART Note and Baseline ( $F(1, 82) = 2.87, p < .001$ ). As shown in Figure 8.4, SMART Note was rated higher on all nine purpose items. There was also a significant difference among the nine items ( $F(1, 82) = 5.25, p < .001$ ). There was not a significant interaction between condition and items in the purpose dimension ( $F(1, 82) = .425, ns$ ).



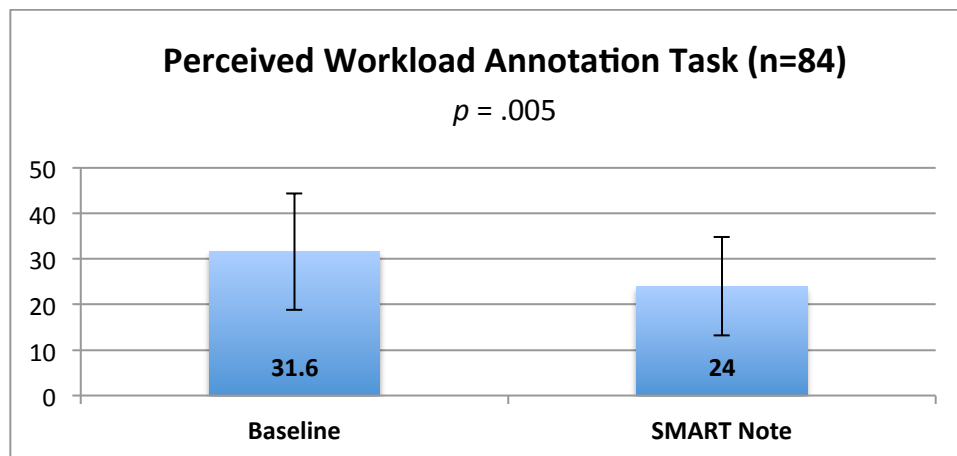
**Figure 8.5. SMART Note was rated significantly higher on the physical strategies dimension for 10 items. Differences among items were also significant.**

Finally, on the physical strategies dimension, there was again a significant difference between SMART Note and Baseline ( $F(1, 82) = 4.45, p = .038$ ). There was also a significant difference among the 15 items ( $F(1, 82) = 12.40, p < .001$ ) and a marginally significant interaction between condition and items in the physical strategies dimension existed ( $F(1, 82) = 1.58, p < .079$ ). The means are shown in Figure 8.5.

Although the ANOVA did not indicate a strong interaction, the figure suggests that SMART Note was not rated higher than Baseline for all items. To further examine these means, Tukey t-tests were calculated to compare SMART Note to Baseline on each of the 15 items. There was not a significant difference between SMART Note and Baseline on items six (summarize educational material in my own words), eight (create a practice test), 11 (make note cards), or 15 (orally recite what I've read or watched after each section/main topic). This is not at all surprising, as none of these particular strategies were relevant to this study. Recall that the AREQ is based on all common active reading strategies so that it is useful in a variety of assessment scenarios. Thus, not all items will be relevant to every study on active reading experience. Additionally, the Baseline prototype was rated higher on item 13 (make study questions). SMART Note was rated higher on the other 10 items, most of which are far more relevant to the specific active reading scenario laid out for this study.

#### 8.4.2.2 Perceived workload as measured by the NASA-TLX

**SMART Note users rated workload for both the annotation and study tasks lower than Baseline users.** Figure 8.6 illustrates that SMART Note overall workload in the annotation task was lower ( $24.0 \pm 10.8$ ) than the Baseline prototype ( $31.6 \pm 12.8$ ), a statistically significant difference of 7.6 (95% CI, 2.4 to 12.7),  $t(82) = 2.92$ ,  $p = .005$ .

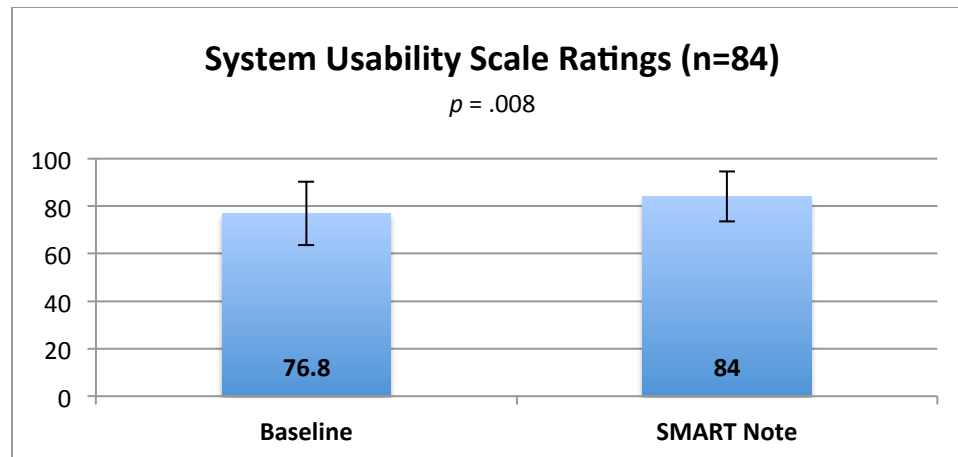


**Figure 8.6. Perceived workload in the annotation task was significantly lower for SMART Note users than for Baseline users.**

Due to a somewhat platykurtic distribution of means in the study task data, a Mann-Whitney U test was administered to determine whether there were significant differences in average workload scores between SMART Note and Baseline participants. Distributions of the overall workload scores for both conditions were similar, as assessed by visual inspection. The overall workload score for the study task was not statistically significantly different between SMART Note ( $Mdn = 23.4$ ) and Baseline ( $Mdn = 29.2$ ),  $U = 779$ ,  $z = -0.922$ ,  $p = .357$ . These results suggest that although participants didn't differ significantly in their perceptions of workload when it comes to reviewing and studying their annotations, SMART Note is significantly less mentally demanding than the Baseline prototype when it comes to active reading and annotation.

#### 8.4.2.3 Usability as measured by the SUS

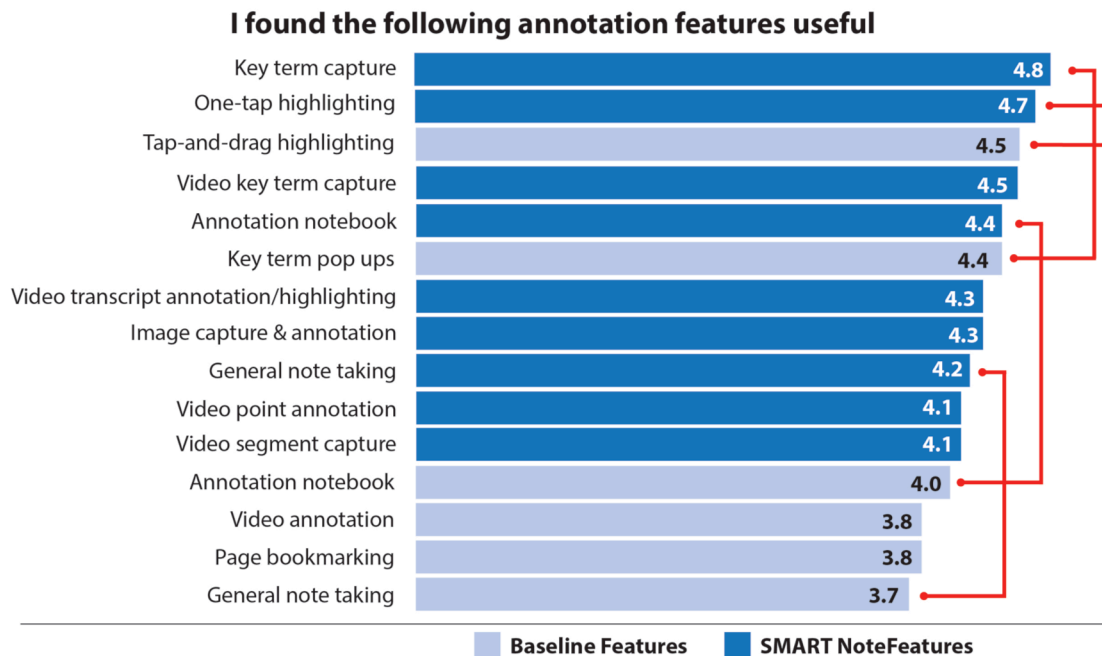
**SMART Note participants offered significantly higher usability ratings than that of the Baseline participants.** An SUS score above a 68 is considered above average, and both the Baseline and SMART Note prototypes scored well above this threshold. As seen in Figure 8.7, SMART Note was rated easier to use ( $84.0 \pm 10.6$ ) than the Baseline prototype ( $76.8 \pm 13.3$ ), a statistically significant difference of 7.2 (95% CI, -2.4 to 2.0),  $t(82) = -2.74$ ,  $p = .008$ .



**Figure 8.7. SMART Note usability ratings were significantly higher than ratings of the Baseline prototype.**

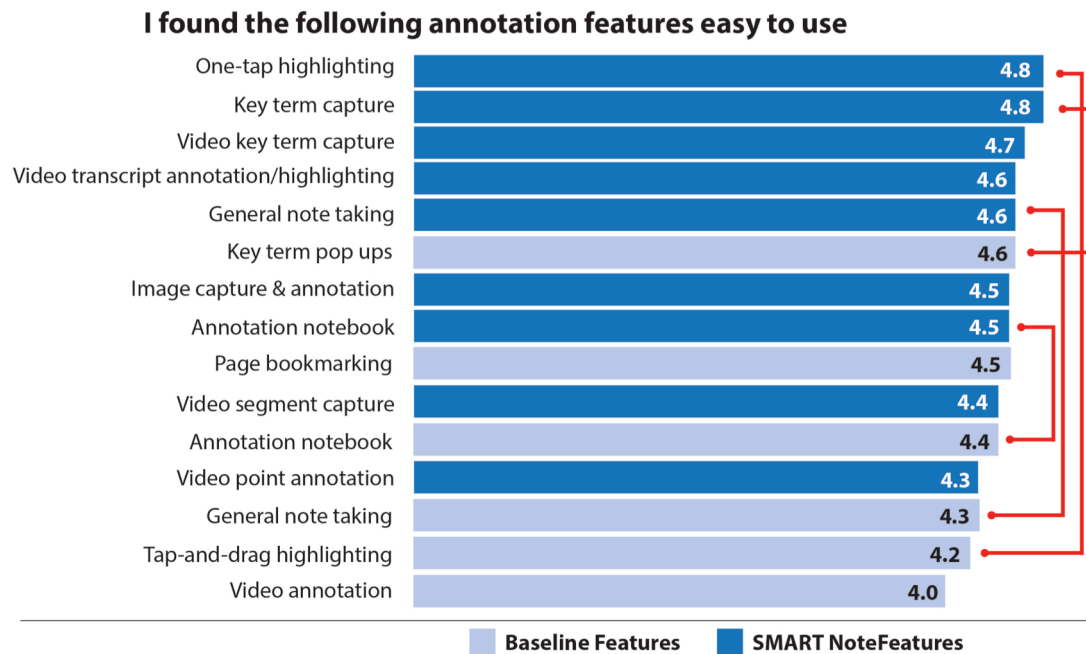
#### 8.4.2.4 Feature-level utility as measured by a three-part questionnaire

**A majority of SMART Note annotation features rated higher than Baseline features on three dimensions of utility:** perceived usefulness, perceived ease of use, and whether participants believed they would frequently use each of the features if they were required to use the tablet textbook system for a course. Again, it is important to note that each system offers different features. Thus, an apples-to-apples comparison is not possible.

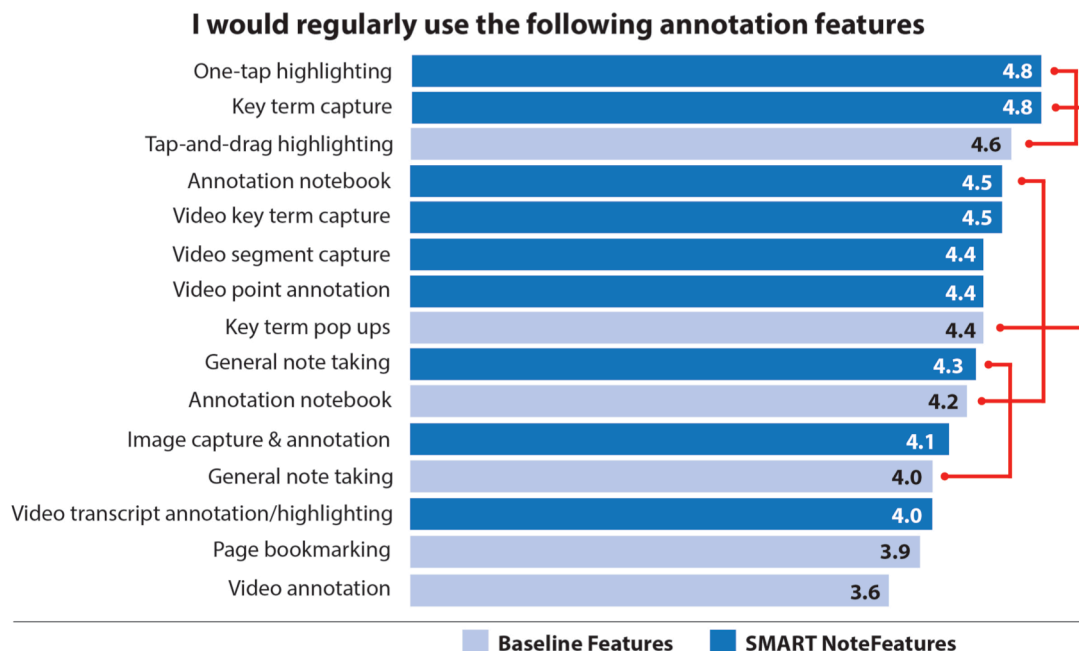


**Figure 8.8. SMART Note and Baseline usefulness ratings. Brackets indicate features provided by both systems, which are, therefore, directly comparable.**

However, we can see that all nine SMART Note annotation features rated above 4.0 on the *usefulness* dimension, with only two Baseline features passing that threshold, as shown in Figure 8.8. Additionally, all SMART Note and Baseline annotation features rated 4.0 or higher on the *ease of use dimension*, as shown in Figure 8.9. Finally, all SMART Note and Baseline annotation features rated at or above 4.0 on the *frequency of use dimension*, as shown in Figure 8.10.



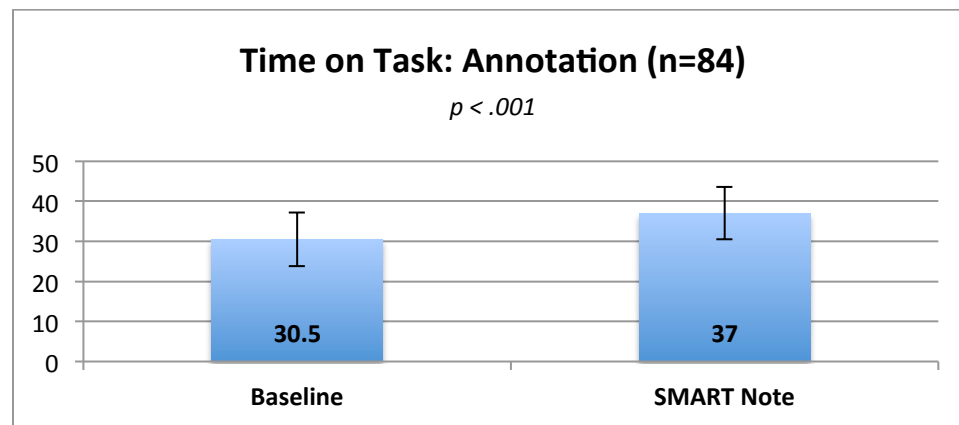
**Figure 8.9. SMART Note and Baseline ease of use ratings. Brackets indicate features provided by both systems, which are, therefore, directly comparable.**



**Figure 8.10. SMART Note and Baseline frequency of use ratings. Brackets indicate features provided by both systems, which are, therefore, directly comparable.**

### 8.4.3 Learning process findings

Independent-samples t-tests were conducted to compare learning processes on two measures between the SMART Note and Baseline conditions: 1) engagement, as measured by time on task during annotation and study tasks, and 2) number and type of annotations made during the annotation task. Data are mean  $\pm$  standard deviation unless otherwise stated.



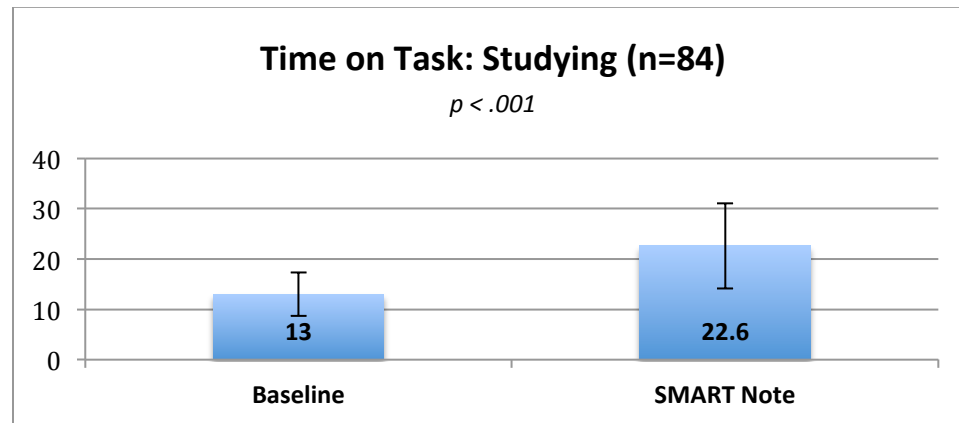
**Figure 8.11. SMART Note participants spent significantly more time engaged in the annotation task than Baseline participants.**

#### 8.4.3.1 Time on task

**SMART Note participants spent significantly more time engaged in both active reading tasks: *annotation* and *studying*.** As shown in Figure 8.11, on average, SMART Note participants spent significantly more time in minutes ( $37.0 \pm 6.5$ ) engaged in the annotation task than Baseline participants ( $30.5 \pm 6.7$ ), a statistically significant difference of 6.5 (95% CI, -9.6 to -4.2),  $t(82) = -5.05$ ,  $p < .001$ .

The assumption of homogeneity of variances was violated for study task data, as assessed by Levene's test for equality of variances ( $p = .001$ ). Thus, the Welch t-test was performed on these results to determine whether differences in time on task were significant. SMART Note participants spent significantly more time in minutes ( $22.6 \pm 8.5$ ) engaged in the study task than Baseline participants ( $13.0 \pm 4.3$ ), a difference of 9.6 minutes  $\pm 4.2$ . As shown in Figure 8.12, there was a statistically significant difference in mean time on task between SMART Note and Baseline participants,  $t(60) = -6.53$ ,  $p <$

.001. These results suggest that SMART Note engages students in key active reading tasks considerably more than Inkling Habitat.

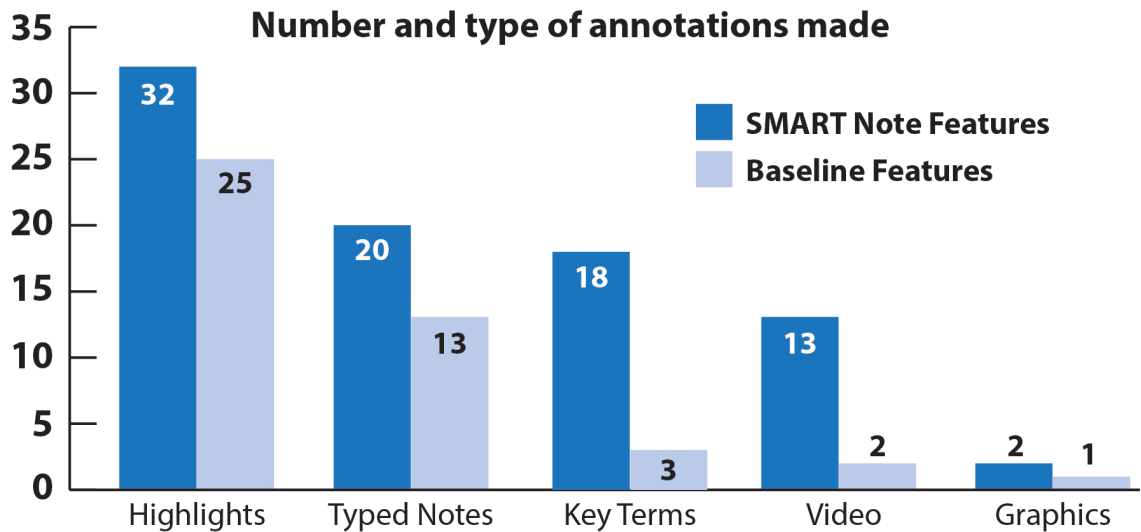


**Figure 8.12. SMART Note participants spent significantly more time engaged in the study task than Baseline participants.**

#### 8.4.3.2 Number and type of annotations made

**SMART Note participants made significantly more annotations than Baseline participants.** This finding is not necessarily surprising, given that there were more opportunities for SMART Note users to make annotations than Baseline users. However, this does speak to the robustness of each prototype.

Upon further analysis, results for total number of annotations made was not normally distributed for either the SMART Note or Baseline conditions, as assessed by Shapiro-Wilk's test ( $p < .05$ ). Rather, the data was moderately positively skewed, requiring a square-root transformation, which resulted in normal distribution. Based on this transformation, SMART Note participants made more annotations overall ( $8.8 \pm 1.3$ ) than Baseline participants ( $5.4 \pm 1.1$ ), a statistically significant difference of 3.4 (95% CI, -3.2 to -2.1),  $t(78) = -9.84$ ,  $p < .001$ . Figure 8.13 breaks down annotations by type and shows that SMART Note made more annotations over each type of media than Baseline participants. These findings suggest that in general, SMART Note encourages more note taking over multimedia content than the Baseline prototype, as well as similarly designed tablet textbook platforms currently on the market.



**Figure 8.13. SMART Note participants made more annotations over each type of media than Baseline participants.**

#### **8.4.4 Learning outcome findings**

Independent-samples t-tests were conducted to compare learning outcomes between the SMART Note and Baseline conditions based on quiz scores. Data are mean  $\pm$  standard deviation unless otherwise stated.

##### **8.4.4.1 Achieving inter-rater reliability for short answer quiz scores**

Inter-rater reliability was achieved by counting the number of times both scorers agreed on the total score (number of points out of 18) for an individual participant, as well as the number of times they only differed by one or two points. Table 8.3 shows this breakdown.

Level of Agreement	Percentage agreement
Total score was the same	33.3% (n=28)
Total score differed by only one point	34.5% (n=29)
Total score differed by only two points	22.6% (n=19)
Total score differed by three points	3.6% (n=3)
Total score differed by four points	6.0% (n=5)

**Table 8.3. Level of agreement between two raters on all questions**

Thus, there was a  $\leq$  one-point difference between raters for 67.8% of participants and a  $\leq$  two-point difference 90.4% of the time. Given that these were short-answer



questions open to a wide range of interpretation regarding accuracy and completeness of the answer, this seems to be a pretty solid level of agreement.

To analyze inter-rater reliability, Cohen's Kappa ( $k$ ) was conducted on each of six individual quiz questions, as well as on the total scores for all six short answer questions. To effectively run Cohen's Kappa, nominal values 3, 2, 1, and 0 were used for individual quiz questions, and total scores were assigned letter grades: A ( $\geq 90\%$ ), B ( $\geq 80\%$ ), C ( $\geq 70\%$ ), D ( $\geq 60\%$ ) or F ( $\leq 59\%$ ). Kappa is always less than or equal to one. A value of one implies perfect agreement and values less than one imply less than perfect agreement. Although perfect agreement is rare, Altman (1991) provides the most commonly used agreement model, which is outlined in Table 8.4. Once inter-rater reliability was examined, scores for individual questions, as well as total quiz scores were averaged to establish a single score for each participant.

<b>Kappa</b>	<b>Description</b>
Less than 0.20	Poor agreement
0.20 to 0.40	Fair agreement
0.40 to 0.60	Moderate agreement
0.60 to 0.80	Good agreement
0.80 to 1.00	Very good agreement

**Table 8.4: Cohen's Kappa agreement model**

When scores for quiz questions were analyzed individually, Kappa for all six questions fell within the moderate range. This generally average level of agreement is

<b>Question</b>	<b>% agreement</b>	<b>Kappa</b>
<b>1</b>	71.4%	.439 (moderate)
<b>2</b>	69.0%	.559 (moderate)
<b>3</b>	69.0%	.507 (moderate)
<b>4</b>	63.1%	.418 (moderate)
<b>5</b>	73.8%	.560 (moderate)
<b>6</b>	67.9%	.414 (moderate)

**Table 8.5: Cohen's Kappa agreement model**

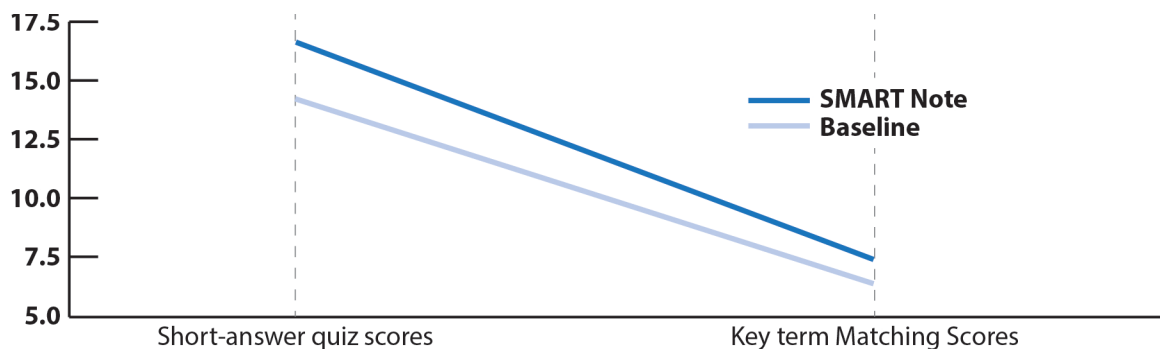
likely due to the fact that even small disagreement in the accuracy of an answer could considerably alter the Kappa. When added together and given a letter grade, the degree of agreement was also moderate ( $k=.444$ ) at 56.0%. Again, this is likely because there were

only 18 points possible, even a one-point disagreement in total score could mean the difference between an A and B, a B and a C, etc. Table 8.5 shows the percentage of agreement and the Cohen's Kappa rating for each of the six questions.

After inter-rater reliability was determined for the short answer portion of the quiz, total quiz scores were averaged to establish a single score for each participant. Average scores per question for SMART Note participants were higher than Baseline participants for all six questions. Independent-samples t-tests were conducted to compare quiz scores for both short answer and key term matching questions. Data are mean  $\pm$  standard deviation unless otherwise stated.

#### 8.4.4.2 Short-answer and key term matching quiz scores

**Participants who used SMART Note scored higher on both the short answer and key term matching portions of the quiz.** An ANOVA with one within variable (quizzes with two levels, percent correct on short answer and percent correct on key terms) and one between variable (condition with two levels, SMART Note and Baseline prototype) was calculated to examine the learning measure scores. There was a significant difference between SMART Note and Baseline ( $F(1, 82) = 12.39, p = .001$ ). As shown in Figure 8.14, SMART Note users scored approximately 10% higher on both the short answer and key term matching portions of the quiz. There was also a significant difference between the two quiz types ( $F(1, 82) = 5.40, p = .023$ ). Participants averaged about 3% higher on the key term matching than the short answer portion. There was not a significant interaction between condition and quiz type ( $F(1, 82) = .225, ns$ ). These findings suggest that SMART Note has the potential to improve learning outcomes over educational material.



**Figure 8.14. SMART Note users scored approximately 10% higher on both the short answer and key term matching portions of the quiz. There was also a significant difference between the two quiz types. Participants averaged about 3% higher on the key term matching than the short answer quiz.**

#### **8.4.5 Relationships between active reading experience and learning**

To provide further insight into the relationships among usability, active reading experience, and learning outcomes, Pearson's Correlation analysis was conducted for several measures.

**As time on task and number of annotations made increased, so did quiz scores.** There was a small positive correlation between short answer quiz scores and time spent annotating,  $r(82) = .264, p = .015$ , as well as time spent studying,  $r(82) = .280, p = .010$ . Likewise, there was a small positive correlation between key term matching scores and time spent annotating,  $r(82) = .248, p = .023$ , as well time spent studying,  $r(82) = .141, p = .202$ . There was also a small positive correlation between number of annotations made and short answer quiz scores,  $r(82) = .243, p = .030$ , as well as number of annotations made and key term matching scores,  $r(82) = .261, p = .019$ .

**Additionally, as usability ratings increased, so did quiz scores.** There was a small positive correlation between usability and short answer quiz scores,  $r(82) = .253, p = .020$ . There was also a small positive correlation between usability and key term matching scores,  $r(82) = .265, p = .015$ .

**Finally, as active reading experience ratings increased, perceived cognitive load decreased.** There was a moderate negative correlation between perceived workload during the annotation task and active reading experience ratings,  $r(82) = -.490, p < .0005$ . And there was a strong negative correlation between perceived workload during the study task and active reading experience ratings,  $r(82) = -.525, p < .0005$ . However, there was no significant correlation between quiz scores and active reading experience ratings.

#### **8.4.6 Qualitative findings**

This section reports on results from both the semi-structured interviews and observational notes collected during the active reading sessions. A few of the research sessions ran longer than the allotted two-hour timeframe because participants were given as much time as they needed for the annotation, study, and quiz portions of the study. This caused a few participants to be short on time at the end. Therefore, six of the 84 participants (four SMART Note, two Baseline) did not participate in the semi-structured

OVERALL EXPERIENCE WITH TABLET TEXTBOOK	
BASELINE PROTOTYPE	SMART NOTE PROTOTYPE
<b>Usability</b>	<b>Usability</b>
Easy, simple, easy to use [16]	Easy, simple, easy to use [22]
Easy/simple to learn [2]	Easy to make notes with just one tap [2]
Easy to understand [6]	<b>Utility</b>
It's harder to take notes using the keypad than it is with pencil and paper [2]	Catered to my main study habits [2]
It took me awhile to get used to the system [1]	Helpful [6]
<b>Utility</b>	Convenient [9]
Useful [2]	Interactive, more interactive than a book [3]
Interactive, hands-on [2]	Variety of features was useful [12]
I like the different features a lot [2]	Good tool to use for studying [6]
It's nice to have all books in one place [4]	Helped me to take my time [2]
<b>Experience</b>	Tablet helped better organize my notes [14]
I like the digital format [2]	Efficient [5]
Fine, ok [2]	<b>Experience</b>
Good [7]	Kept my attention, focus [2]
Smooth [1]	Good [3]
Great [2]	Straightforward [1]
I didn't like it as much as I thought I would [1]	Modern [1]
Good experience, but personally wouldn't use it because I like to have physical book [2]	More interesting than a book [2]
I liked it, but I am used to taking notes with paper and pencil [3]	I liked it, but I would still make notes on paper to help me remember [7]
Looking at the digital screen for a long time was difficult [2]	<b>Structure/Design</b>
	Visual design was useful [4]
	Well organized [4]

**Figure 8.15.** The affinity diagram provides an overview of participant responses to interview questions about general user experience. Numbers in brackets indicate how many participants made statements of that type.

interview. Thus, for this portion of the data, the overall  $n=78$  (Smart Note (S) = 38; Baseline (B) = 40).

Participants in both conditions reported the system they were assigned was generally easy to use. Participants cited “ease of use” (Sn=35, Bn=30), “engaging interactivity” (Sn=20, Bn=17), and the system’s ability to concatenate all annotations in one place (Sn=15, Bn=12) as attractive features. On the other hand, some participants in both conditions said they would still prefer to take notes on paper (Sn=14, Bn=16) and that sometimes-cumbersome interaction mechanics (Sn=9, Bn=19) were challenging. Figure 8.16 provides an affinity diagram of the most common responses to questions about the overall active reading experience.

The following sections detail four main themes that emerged from the semi-structured interviews and observational notes. It is worth noting that these themes can also be aligned to core activities in the original active reading framework: annotation, reorganization, browsing, and cross-referencing. This alignment helps illuminate the fact that although learners are engaging in annotation and study activities in a modern digital reading environment, their thoughts about the learning process may still be grounded in the most fundamental active reading strategies.

#### *8.4.6.1 Participants valued annotation tools and interaction patterns that promoted efficiency and limited distractions from the flow of reading and studying*

In both the SMART Note and Baseline conditions, participants repeatedly commented on their desire to make and study annotations quickly and efficiently. Furthermore, both conditions yielded observational data and interview feedback that indicated which tools and interaction patterns learners found favorable, as well those that presented challenges. In both conditions, several participants said typing notes using the keypad was undesirable (Sn=8, Bn=12). Figure 8.16 provides an affinity diagram of the most common responses to questions about highlighting, note taking and key term annotation, however three key themes should be noted.

**When it comes to highlighting, participants conceptually link notions of efficiency to being less distracted from act of reading.** Many participants were generally positive about the highlighting functionality in both the SMART Note and

HIGHLIGHTING, NOTE TAKING, AND KEY TERM ANNOTATION	
BASELINE PROTOTYPE	SMART NOTE PROTOTYPE
<b>Usability</b>	<b>Usability</b>
Highlighting was easy use, simple [23]	Highlighting was easy to understand [2]
Highlighting was difficult, hard to do [5]	Highlighting was easy, simple [16]
Highlighting was clumsy [2]	Key term capture was easy to use [10]
Highlighting was time consuming, slow [2]	Taking notes with keypad was difficult [6]
Highlighting was frustrating [2]	Typing notes with keypad is clumsy [2]
Key terms were simple, easy to use [6]	<b>Utility</b>
Liked pop up definitions for key terms [2]	Highlighting was fast, quick, efficient [21]
Taking notes over key terms was time consuming [9] or distracting [9]	Highlighting was convenient [12]
Taking notes with keypad was difficult [12]	I was able to keep reading without getting side tracked [2] or distracted [9]
<b>Utility</b>	Key term capture was helpful [2]
Highlighting was helpful, useful [3]	Key term capture helped me pay more attention to definitions [3]
Highlighting distracted me from reading [2]	It would be better if key term capture saved a simplified version of the definition [2]
Key term pop ups were useful, helpful [2]	Key term capture is boring [2]
Key terms were hard to study because I couldn't highlight them [25]	I prefer to put key term definitions in my own words [2]
<b>Perceived Advantages/ Disadvantages of Functionality</b>	<b>Perceived Advantages/ Disadvantages of Functionality</b>
Highlighting was ok once I got used to it [5]	Highlighting was convenient. I could just tap and keep reading without distraction [4]
When I couldn't highlight key terms, I thought I was doing something wrong [3]	Highlighting was fast; quicker than with a pen or with your finger [2]
Annotating key terms was time consuming [2]	I didn't want to highlight whole sentences, I wanted to highlight words or phrases [14]
The fact that I couldn't highlight the key terms was aggravating [3]	I liked that with just one tap, key terms were easy to save and review [3]
I didn't like that I had to bookmark pages key terms were on to review them [2]	

**Figure 8.16.** The affinity diagram provides an overview of participant responses to interview questions related to highlighting, note taking, and key term annotation. Numbers in brackets indicate how many participants made statements of that type.

Baseline prototypes. However, there were notable differences in the ways SMART Note and Baseline participants characterized their preferences. For example, a majority of SMART Note participants said that one-tap highlighting facilitated “fast”, “quick”, or “efficient” highlighting (n=21) that limited distractions from reading (n=11). One participant commented on the accuracy of SMART Note’s one-tap highlighting, asserting that it is “better than other apps on my phone and iPad. You have to swipe, and it can be really touchy. With this, I didn’t have to mess with that. I could just tap to highlight and keep reading. It was fast. But even better, it didn’t distract me from reading” [P6]. Another participant indicated that SMART Note’s one-tap highlighting is less distracting than tap-and-drag methods: “I feel like tapping and having to drag does take you out of the flow [of reading].” But with one-tap highlighting, “I read over the sentence, I knew I wanted to save it, [and] I can just keep reading.” [P71]. Observational data confirmed this, as none of the SMART Note users exhibited trouble with one-tap highlighting functionality. However, several noted that they would prefer more freedom in highlighting rather than be forced to highlight at the sentence level (n=14).

On the other hand, although many participants indicated that Baseline’s tap-and-drag highlighting was easy to use (n=23), observational data suggested that many struggled to highlight selections accurately at least once – some multiple times – during the annotation task (n=30). One Baseline participant articulated this struggle: “Highlighting was okay I guess, once I got used to it. But even then, it took time to highlight, and if my finger moved too far off the words, it highlighted the wrong line. Then I had to take time to fix it before I could go on” [P30]. This delay is due to tap-and-drag mechanics, which require more precision than one-tap highlighting (both of which are visualized in Chapter 6, page 96).

**SMART Note’s key term capture supported active reading better than Baseline’s key term pop ups, which couldn’t be highlighted or otherwise saved for future review.** Although most participants in both groups said they appreciated key term popups, a pervasive complaint among Baseline users was the inability to highlight or otherwise easily save key terms (n=25). Several Baseline participants said it was unlikely that they would take the time to type key term definitions by hand (n=16), citing that this is too time consuming (n=9) and/or distracting (n=9). Furthermore, 27 of 42 Baseline

users attempted to highlight key term definitions and then became frustrated when they realized they couldn't. According to one Baseline participant, this was "a little aggravating. I wanted to...highlight the key terms ...but I couldn't. I had to either type the definition or go back to that page and click on all the popups again. That's too time consuming...too confusing" [P31]. Alternatively, SMART Note participants often mentioned their appreciation for the key term capture feature, noting that it was "easy to use" (n=10) and/or "helpful" (n=5). One participant said reviewing key terms was "really easy because you just click the button and it would save the term and then you just go back and look at the definitions so it was all in one place, which was nice and easy" [P5].

**SMART Note's easy-to-use video annotation features better facilitated more efficient video annotation than the Baseline prototype, which required users to type annotations over video by hand.** Among the most common compliments of the SMART Note prototype were that the variety of annotation features helped learners focus more on the information (n=18) and made it easy to make annotations without interrupting the flow of watching/studying (n=12). Furthermore, SMART Note participants articulated the process of watching and annotating video as generally positive (n=28), noting that video annotation features were "easy to use" (n=18) and that individual annotation tools such as transcript annotation and/or video segment capture "helpful" (n=3, n=12) and allowed for a variety of annotations with "just one tap" (n=30). One SMART Note participant also said the easy-to-use video annotation features helped him "keep up" with the video. "It was nice how the key terms as they went through showed up and you could click [to save them]," he said [P67]. Another participant noted that video segment capture also helped him stay focused on studying the video content: "if I already know what the beginning of the video is then, and then sometimes if I would watch the entire video again then by the time I get back to the part that I needed to watch then it's like my focus is gone, so ... [with segment capture] you don't have to waste time watching stuff that you already know" [P69].

Several Baseline participants also said it was functionally easy to make annotations over videos (n=17). However, many Baseline participants also asserted that having to pause and rewind was "difficult" (n=15), "tedious" (n=2) and/or "time-consuming" (n=3). According to one Baseline participant, "If I wanted to take notes, ... I



VIDEO ANNOTATION	
BASELINE PROTOTYPE	SMART NOTE PROTOTYPE
<b>Usability</b>	<b>Usability</b>
Video annotation was simple, easy to use [17]	Video annotation was easy to use [18]
Replaying and rewatching video was easy [2]	I had to try harder to make the right annotations using all the different tools [7]
Video annotation was tedious [2]	It was harder to understand how to use video annotation than the other features [3]
I got frustrated and gave up [2]	Point annotation was frustrating because typing with the keypad is awkward [4]
Bookmarking, rewinding, and re-watching video to review it was difficult [15]	
<b>Utility</b>	<b>Utility</b>
Video annotation was helpful [2]	Transcript made video easy to follow [6]
Bookmarking videos was helpful [3]	Transcript helped me process the video [16]
Video annotation was distracting because the video kept playing [5]	Transcript annotation was helpful [3]
Annotating video was time consuming [3]	Different types of video annotation helped me remember the information [21]
<b>Perceived Advantages/ Disadvantages of Functionality</b>	Annotation features made me pay more attention to the information in the video [18]
I didn't annotate videos because it was difficult [10]	Segment capture helped me just focus on parts of the video I needed to review [12]
I would prefer to take video notes on paper [4]	<b>Perceived Advantages/ Disadvantages of Functionality</b>
I couldn't easily take notes over video without stopping and rewinding a lot [4]	I could do a lot of different kinds of annotation over video with just one tap [11]
	I could just touch a button and the notes would show up right below the video so I could see what I was doing [19]
	Transcript let me annotate with one tap and keep listening to/watching video [17]
	Transcript and/or segment capture made it so I didn't have to rewatch the whole video to study [9]
	Video key term capture allowed me save a list of key terms without having to look up the definitions [13]
	Video annotation features were challenging at first; I was confused about what to do [7]

**Figure 8.17. The affinity diagram provides an overview of participant responses to interview questions related to video annotation. Numbers in brackets indicate how many participants made statements of that type.**

had to stop the video and then go to the little note-taking thing and then start it all over. It was distracting, confusing. I didn't like it. I would have preferred a piece of paper and a pencil" [P41]. The affinity diagram in Figure 8.17 includes an overview of the most common sentiments about video annotation in both systems.

#### *8.4.6.2 SMART Note participants engaged in more video annotation than Baseline participants, many of whom said they gave up on video annotation altogether*

It is important to note that video annotation in each system was very different, with SMART Note providing four different annotation methods (transcript annotation, key term capture, segment capture, and point annotation), while the Baseline prototype only provided one (general note taking). Thus, it is not appropriate to make a linear comparison between the two. However, it is worth noting that far more SMART Note participants indicated that their video annotation features were robust and/or engaging than Baseline participants. Two key themes emerged from interviews.

**Several SMART Note participants noted that the variety of video annotation features facilitated the creation of a more thorough set of video annotations than they would have made on their own.** According to one SMART Note participant, "I thought that it honestly made notes better for me than I could have made for myself" [P73]. Likewise, many SMART Note participants noted that different types of video annotation helped them "remember information" (n=21) and helped them "pay more attention to information in video" (n=18).

On the other hand, a notable number of Baseline participants said they didn't spend much time annotating video (n=10), with some saying Baseline video annotation was "time consuming" (n=3) and/or otherwise "difficult" (n=15). Additionally, several Baseline participants indicated that although video annotation was relatively easy to do, it wasn't a very engaging activity. One Baseline participant articulated the experience as "simple," noting that she "didn't really feel compelled to make notes over the video. The design is like they just want you to focus on watching it. And the bookmark button or take notes button are kind of off to the side. I really didn't remember to make notes [over videos]" [P82].

**Although participants in both conditions said video annotation was easy to do, SMART Note participants more frequently described video annotation features as useful, while Baseline participants more frequently described video annotation features as frustrating, time consuming, and/or distracting.** Transcript annotation and video segment capture were among the most popular SMART Note video annotation features. Participants often noted that these two features in particular made it easier to annotate video because it allowed them to focus on specific parts of the video they wanted to return to later while studying (n=21). Likewise, participants noted that video key term capture allowed them to save a list of key terms they wanted to study without having to look up definitions or re-browse the body of the chapter to find them (n=13). On the other hand, Baseline users were much less complimentary of their video annotation features, saying video annotation was “distracting” (n=5), “time consuming” (n=3), and/or “frustrating” (n=2) or “tedious” (n=2). Again, this was likely due to the fact participants felt that bookmarking, rewinding, and re-watching video to review it was difficult (n=15). Quantitative data further supports these comments, as SMART Note participants made, on average 12.5 annotations over videos, while the Baseline average was only 2.2.

Additionally, observational data further illuminated participants’ video engagement. On average, SMART Note users re-watched portions of videos collected in their annotation notebook 2.48 times, while Baseline users re-watched portions of videos that were bookmarked in their annotation notebook 1.31 times. Likewise, only four SMART Note participants re-watched one or both of the videos in their entirety, while 17 participants did so with the Baseline prototype. Additionally, on average, SMART Note participants made 12.5 annotations over videos, while the Baseline average was only 2.2.

#### *8.4.6.3 Robust filtering capabilities and multiple organizational structures for annotations helps learners make sense of a large collection of annotations over multiple media formats*

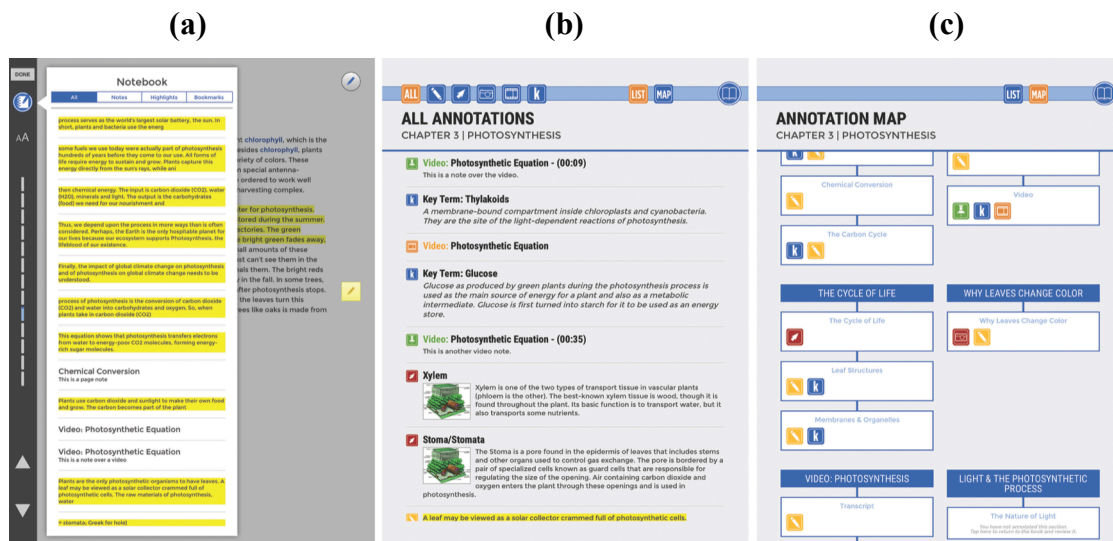
Overall response to both annotation notebooks was positive, with participants in both conditions citing ease of use (Sn=28, Bn=27) and having all annotations in one place (Sn=31, Bn=29) as the most useful features. Alternatively, a number of participants also noted they would still prefer to put annotations “in their own words...on paper” (Sn=11,

REORGANIZATION OF ANNOTATIONS IN DIGITAL NOTEBOOK	
BASELINE PROTOTYPE	SMART NOTE PROTOTYPE
<b>Usability</b>	<b>Usability</b>
Annotation notebook is easy to use [27]	Annotation notebook is easy to use [28]
Long list of annotations was hard to use [9]	Map view is hard to understand [7]
<b>Utility</b>	<b>Utility</b>
Annotation notebook is useful [2]	Annotation notebook is convenient [5]
Annotation notebook is helpful [5]	I prefer to put notes in my own words [11]
I prefer to put notes in my own words [17]	Buttons allowed me to easily save key terms, video segments in the notebook [11]
<b>Organization/Structure</b>	<b>General Organization/Structure</b>
Long list of annotations seems jumbled, disorganized, lacks order [26]	Icons and/or color helped me understand what type of note it was [11]
I like having all my notes in one place [29]	I like having all my notes in one place [31]
I wanted the freedom to move the notes around into my own groupings [16]	Caters to the visual learner [4]
I wanted to reorganize annotations based on what I thought was important [19]	When notes are summarized, filtered by category, I can understand them better [13]
Annotation notebook is boring to look at [2]	Filtering was a good way to reorganize notes over different kinds of content, media [17]
Design is plain [6]	I wanted the freedom to move the notes around into my own groupings [10]
	I wanted to reorganize annotations based on what I thought was important [7]
	<b>List View</b>
	List view helped me organize different kinds of notes together [9]
	List view was overwhelming, confusing [9]
	List view seemed like everything was just thrown together [3]
	<b>Map View</b>
	Map view was like an outline, so I could see the structure of the chapter [12]
	Map view was hard to follow, overwhelming, confusing [13]
	Map view helped me understand the structure of the chapter [18]

**Figure 8.18. Overview of participant responses to interview questions related the digital notebook. Numbers in brackets indicate how many participants made statements of that type.**

Bn=17). Figure 8.18 provides an affinity diagram of the most common responses to questions about the organization of annotations, however four key themes arose related to the systems' automatic reorganization of annotation.

**List view can be confusing, especially in the Baseline prototype, where there were no visual cues or built in structure to help learners understand the nature of individual annotations.** Although participants in both conditions appreciated that list view allowed them to view all of their annotations in one place, this format was, at times, overwhelming for participants in both conditions. As shown in Figure 8.19, there was a considerable difference between Baseline list view (a) and SMART Note list view (b). However, according to one SMART Note user, “List view was just all of the notes thrown together. That didn’t feel as clearly organized to me” [P8]. Several other SMART Note participants noted that list view was “overwhelming” or “confusing” (n=9). This sentiment was even more common among Baseline participants, who had no other option for how to organize their annotations. A considerable number of Baseline participants said list view was “jumbled”, “disorganized”, or “lacks order” (n=26). According to one



**Figure 8.19. Baseline list view (a) concatenated annotations in one long list, with no textual or visual cues regarding the original media source. Additionally, Baseline list view only allowed users to filter by all annotations, highlights, notes, or bookmarks. SMART Note list view (b) included labels, color-coding, and icons that indicated the original media source, as well as the ability to filter notes by media type. SMART Note map view (c) also included color-coded icons and organized annotations according to an outline of the chapter.**

Baseline participant, “I guess the organization was both good and bad. On one hand, it was better than a textbook because you could mark [annotations] and see them in one place...instead of searching and flipping [through pages of the book]. On the other hand, all the highlights were just jumbled together in there. So, when you look at them by themselves, what does it all mean?” [P26]. Several SMART Note participants noted that color-coding, icons, and mitigate confusion. However, the Baseline prototype did not include visual cues.

**Additionally, the ability to filter annotations provided SMART Note participants the ability to further order and categorize annotations in list view, while the Baseline filtering feature was rarely used.** Many SMART Note participants made use of the filtering feature as a way to overcome the potentially overwhelming nature of list view. According to one participant, “Filtering made it easy to organize notes by category. That way, I could find what I was looking for faster and go back and forth between different categories of notes. I liked that a lot” [P63]. Thus, for many SMART Note participants, filtering notes in list view was a good way to organize annotations made over different media formats (n=17). On the other hand, less than half of the Baseline participants used the filtering capabilities provided in the annotation notebook (n=16). One participant said he didn’t find Baseline filtering to be very helpful: “Since the only things you could really do were type notes, highlight, and bookmark, the filtering didn’t really do much. When I tapped those filter buttons, the most overwhelming list – highlights – was still a long jumbled list with everything together” [P57].

**Many SMART Note participants noted that map view was useful for “understanding the structure of the chapter” as it relates to the annotations that were made.** Thus, map view presented SMART Note participants with an alternative when list view was too linear and/or overwhelming. According to one SMART Note user, “I used both [list view and map view], but I liked the map view better because it’s more of a layout of the whole chapter. If I wanted to...look up just one portion of it, then I could just figure out which section it was in and then all the information from just that section was right there” [P66]. Another SMART Note participant commented, “Map view was more complicated. But it was also organized like a map so that I could clearly

see if I missed anything important” [P3]. The Baseline prototype did not include a map view equivalent or any additional organizational structures for learners to choose from.

Based on this feedback, it was clear that in the SMART Note condition, list view and map view served two different purposes. To some extent, list view captured the entirety of learners’ annotations, with some level of structural scaffolding to help them navigate, review, and browse those notes. Furthermore, SMART Note’s list view – with visual cues and multimedia filtering capabilities – was likely more helpful than Baseline’s list view, which did not include similar design affordances or multimedia filtering capabilities. SMART Note’s map view, was often likened to an outline (n=12) that allowed learners to perceive their annotations in the context of the chapter structure. Thus, map view allowed learners to assess the completeness of their annotations by mapping them to the sections in the chapter from which they were made, as well as by alerting learners when they didn’t annotate a particular section of the chapter. This was important to learners who preferred map view, because it served as both a study tool and as a means for evaluating the quality of their annotations collectively. One SMART Note participant summed it up like this: “In the beginning, I looked through [everything I annotated] and then towards the end, I looked at the outline. So I did both [list view and map view]. I think the outline helped me to understand the topics better” [P69].

#### *8.4.6.4 Overall organization and visual design for annotation notebook affects a learner’s ability to easily browse, comprehend, and recall information*

Twenty-three SMART Note participants stated that their annotation were “easy to review” in the annotation notebook, while only six Baseline participants said the same. The affinity diagram in Figure 8.20 outlines the most common responses to questions about studying and reviewing annotations (browsing), however two key themes are worth highlighting.

**SMART Note participants frequently commented on how the use of visual cues in the annotation notebook helped them easily review their notes, while many Baseline participants noted difficulties browsing long lists of annotations.** Several participants said SMART Note “caters to the visual learner” (n=4), and that the visual design of annotations “made them easy to review” (n=10) or “easy to see different types of

BROWSING ANNOTATIONS IN DIGITAL NOTEBOOK	
BASELINE PROTOTYPE	SMART NOTE PROTOTYPE (CONT.)
Usability/Utility	Organization
Annotations are easy to review [6]	List view was a more orderly way to view my annotations than map view [16]
Annotation notebook helped review quickly [5]	List view allowed me to look over different kinds of notes together [9]
Structure/Design	List view forced me to read notes linearly [6]
I like seeing all of my notes in one place [5]	Map view allowed me to jump around between topics and types of notes [8]
Visual design of annotations made them easy to review, browse through [3]	I could see all of my highlights in one place, so I didn't have to flip through a book to find what I highlighted [11]
Visual design of annotations made them hard to review [17]	Map view was hard to review because it wasn't as clear as list view [9]
Organization	List view was easy to read, easy to follow [6]
Reviewing all of my notes in one long list is confusing, hard to follow [14]	Perceived Advantages/Disadvantages of Functionality
Filtering annotations by type was not useful [13]	Transcript and segment capture made it so I didn't have to re-watch the whole video to study [22]
It was hard to review long list because all of the notes blended together [11]	Transcript allowed me to go back through information in the video at my own pace [19]
SMART NOTE PROTOTYPE	Filtering allows me to easily jump between different types of notes [17]
Usability	
Annotations are easy to review [23]	
Structure/Design	
All of the notes together in one place meant I didn't have to search for annotations in the book [21]	
All of the notes together in one place meant I didn't have to go back to the textbook to study [11]	
Visual design of annotations made them easy to review, browse through [10]	
Visual design made it easy to see different types of annotations together [11]	
Color coding and icons made it easy to distinguish different types of notes [14]	

**Figure 8.20. The affinity diagram provides an overview of participant responses to interview questions related to reviewing (browsing) annotation. Numbers in brackets indicate how many participants made statements of that type.**



annotations together” (n=11). Likewise, some said that in all views, color-coding and/or the use of icons made it easier to “distinguish different types of notes” (n=14). According to one participant, SMART Note “was just more organized. And [the annotation notebook] was just laid out in a pattern that was really easy to flip through and ... remember. As opposed to just a ... jumble of things, there [were] icons and it was visual” [P73]. However, the Baseline notebook was met with mixed opinions when it came to how organization affected learners’ ability to study. Although some noted that the Baseline notebook design made it “easy” (n=5) or “quick” (n=6) to review annotations, several said the Baseline structure made annotations hard to review (n=17). According to one participant, “there was no real outline or order to it. It didn't make sense all thrown together in a list because that was hard to follow” [P33]. Several others noted that it was difficult to review notes in a long list because all of the notes “blended together” (n=11).

**The design and structure of SMART Note’s annotation notebook led to easy browsing of during review sessions.** This point was particularly salient when it came to how participants articulated the experience of reviewing highlights in the annotation notebooks. Recall that SMART Note’s one-tap highlighting allowed learners to highlight at the sentence level by tapping any part of a sentence, while Baseline’s tap-and-drag highlighting required a more complex interaction pattern (as visualized in Chapter 5, page x). However Baseline highlighting also allowed learners to highlight more freely individual words, phrases, etc.

Several SMART Note participants said they liked that they could see all of their highlights in one place because it meant that they didn’t have to return to the body of the chapter to browse highlighted sentences (n=11). However, a few Baseline participants said that when only single words or phrases were highlighted using the tap-and-drag method, those annotations were no longer meaningful when isolated in the annotation notebook (n=6). One Baseline participant said, “I should have highlighted more because I only highlighted little sections instead of the whole thing. I should have highlighted the whole entire definition. ... So [then] you would have to go back to the page and see what you were talking about. Because I only highlighted a couple words and then I realized, ‘Oh, wow, what was this even talking about?’ So, I had to go back” [P53]. Additionally,

several Baseline users said the list of annotations isolated from their original location in the body of the chapter was “confusing” and/or “hard to follow” (n=14).

Additionally, several SMART Note participants noted that video transcript annotation and video segment capture were particularly influential when it came to easily reviewing annotations later. More than half of the SMART Note participants used transcript annotation and/or segment capture to review video content (n=22), and nearly as many said that transcript annotation allowed them to go back through video information “at my own pace” (n=19). Finally, 17 participants said that filtering allowed them to effectively jump between different types of notes while browsing.

#### *8.4.6.5 Organization, design, and structure are related to learners’ ability to make sense of a collection of annotations*

Participants in both conditions also commented on the ways in which organization or lack thereof and design or structure helped them understand collections of annotations over information delivered in different media formats. Likewise, several specific features were more useful than others for solidifying concepts annotated in more than one format. The affinity diagram in Figure 8.19 provides an overview of responses to questions about sense making, however one theme was particularly noteworthy.

**SMART Note participants were far more satisfied than Baseline participants with the ways in which organization and design helped them distinguish among different types of annotations.** As previously noted, several SMART Note participants compared map view to an outline and said this structure helped them see how different “concepts” or “ideas” related to one another (n=11). Several also noted that the map view helped them “connect different concepts” in the chapter (n=12) and alerted them when they had missed “something important” (n=16), both of which were useful when studying. Moreover, some noted that the integrated icons that indicated the relationship between an annotation and its original source (i.e., video, text, image, etc.) and the overall structure of list view made it easy to remember notes (n=9). Related to these points, one SMART Note participant said, “... those button filters at the top ... helped me see my notes based on what the kind of format was. Like was it a video or was it a highlight? That helped me remember things” [P84].

CROSS-REFERENCING ANNOTATIONS AND BODY OF THE TEXT	
BASELINE PROTOTYPE	SMART NOTE PROTOTYPE
Organization/Design	Organization/Design
Ability to jump back and forth between book and annotations is convenient [7]	Map view helped me connect different concepts from the chapter [12]
All of my notes were all jumbled together [3]	Map view let me see if I missed anything important and then go back to review those sections if I wanted to [16]
I couldn't really separate video notes from my other notes [7]	Color coding and icons made it easy to remember different types of notes [9]
Having to jump back and forth between the book and my notes was time consuming [7]	Visual design made it easy to see different types of annotations together [11]
Understanding	Understanding
It was hard to make sense of all my notes when they were all mixed together [13]	Map view was like an outline, which helped me see how different concepts, information related to one another [11]
Jumping back and forth between the book and my notes was disorienting, confusing [12]	Transcript made video more concrete [17]
It was hard to remember my notes after just reading through them [9]	Transcript helped me better understand what the video was explaining [21]
	Viewing annotations from different media types helped me remember [8]

**Figure 8.21. The affinity diagram provides an overview of participant responses to interview questions related to making sense of annotations. Numbers in brackets indicate how many participants made statements of that type.**

On the other hand, although several Baseline users said the ability to jump back and forth between the body of the text and their annotations was “convenient” (n=7), many more were dissatisfied. Some noted that they felt all their notes were “jumbled together” (n=3) and that having to jump back and forth between the body of the text and annotations to make sense of individual annotations was “time consuming” (n=7) and “disorienting/confusing” (n=16), making it “hard to make sense of” all of the annotations together (n=13).

## 8.5 Discussion

Although the preceding study is very narrow in its focus on a singularly defined active reading experience, with a specific type of device, and specialized topic for subject matter, the results speak to a much larger question. As educational textbooks migrate from traditional text-based media to interactive, multimedia formats, how do the learning experience, process, and outcomes change? All of these issues are deeply tied to the use of specific active reading strategies – annotation, reorganization, browsing, and cross-referencing – as part of a formal process for learning with textbooks. Thus, the following sections revisit the research questions outlined for this study with these strategies in mind.

### 8.5.1 *Research questions revisited*

#### 8.5.1.1 *RQ1: How does SMART Note compare to the Baseline prototype on learning experience measures?*

This study confirmed the first hypothesis – SMART Note will better support learners in engaging in fundamental active reading strategies than Baseline strategies and tools – as evidenced by results from The Active Reading Experience Questionnaire. SMART Note yielded a significantly better active reading experience on several dimensions, including the key technological and purpose-driven goals of typical active reading experiences, as well as the key physical strategies learners generally enact during active reading. Additionally, qualitative data indicated that although both systems were generally “easy to use,” SMART Note provided a more robust set of annotation tools and was designed to better support learning. One participant summed it up like this, “I loved...the simplicity, but also the complexity of it. How big it is, but how easy it is to use. It really catered to the student...and that was really nice” [P74].

The second hypothesis – SMART Note will be rated easier to use than the Baseline prototype – was partially confirmed. SMART Note was rated significantly higher on the Systems Usability Scale. And perceived workload during the annotation task was significantly lower for SMART Note participants Baseline participants, while perceived workload during the study task was not significantly different. However, this outcome may be easily explained. Although many SMART Note participants said that the

annotation notebook design facilitated easy browsing and sense making, it is also worth noting that SMART Note participants made far *more* annotations than Baseline participants. Thus, the sheer number and variety of annotations generated in a single study session may have increased cognitive workload while studying. Therefore, “easy to study” may not necessarily reduce perceptions of overall workload. Regardless, qualitative data suggested that participants’ general ability to organize, browse, and make sense of their annotations was better in SMART Note than the Baseline prototype. Finally, feature-level utility ratings were further evidence that in general, more SMART Note annotation features rated higher on usability and utility than most Baseline features.

Collectively, these findings are important because they suggest that in spite of the fact that SMART Note includes more annotation features and a more complex organizational structure for the annotation notebook, the overall user experience is better than systems with fewer features and a simpler notebook design. Although this alone may not lead to better learning outcomes, providing a better learning experience that is designed to specifically support active reading, may result in more engaged, focused, and organized learners in the tablet textbook environment.

LEARNING EXPERIENCE			LEARNING PROCESS		LEARNING OUTCOMES
Active Reading Experience	System Usability	Annotation Task Perceived Workload	Time Spent Annotating	Number of Annotations	Quiz Scores
↑	↑	↓	↑	↑	↑

**Table 8.6. SMART Note performed significantly better than the Baseline prototype on all learning experience measures. Results also showed that although SMART Note participants spent significantly more time annotating the chapter and made significantly more annotations than Baseline participants, SMART Note participants perceived workload for the annotation task to be significantly lower.**

#### 8.5.1.2 RQ2: How does SMART Note compare to the Baseline prototype on learning process measures?

This study also confirmed the third hypothesis – SMART Note users will spend significantly more time engaged in active reading (i.e., reading, annotating, and

reviewing content) than Baseline users – and the fourth hypothesis – SMART Note users will make more annotations than those who use the Baseline strategies and tools. These findings suggest that SMART Note engages students in key active reading tasks considerably more than tablet textbook platforms currently on the market. Thus, not only does SMART Note improve efficiency (as was evidenced by the KLM study outlined in Chapter 6), but it also encourages learners to spend more time and effort focused on active reading tasks, such as annotation and comprehensive note taking.

A few additional observations are relevant regarding the relationships among outcome measures for this study. First, in spite of the fact that SMART Note participants spent more time annotating and reviewing annotations than Baseline participants, SMART Note rated higher than the Baseline prototype on active reading experience and system usability. Thus, although it may take more time and effort to engage in active reading in the SMART Note environment, user experience and usability ratings were uncompromised. Furthermore, although SMART Note participants spent significantly more time annotating the chapter and made significantly more annotations than Baseline participants, perceived workload for the annotation task was significantly lower. This suggests that even though SMART Note was more demanding in terms of time and effort, participants still perceived mental demand associated with studying in the SMART Note environment to be lower. Table 8.6 illustrates these relationships along with the other significant learning experience, process and outcomes results.

Together, these findings are quite impressive. They suggest that by providing more annotation and study tools and removing obstacles, such as superfluous mechanical interaction and confusing design structures, SMART Note facilitates a superior active reading experience on all levels of learning experience, learning process, and learning outcomes.

#### *8.5.1.3 RQ3: How does SMART Note compare to the Baseline prototype on learning outcome measures?*

Finally, this study also confirmed the fifth hypothesis – Quiz scores will be higher for SMART Note users than Baseline users – as SMART Note participants scored significantly higher on short answer and key term matching tests than Baseline. This is

perhaps the most important finding, as it closes the loop on the learning process by confirming that SMART Note has the potential to improve students' performance and relative knowledge gain by better supporting active reading and learning. Of course, these results are less generalizable, as different subject matter and/or test designs may yield different learning outcome results. However, these findings at least indicate that SMART Note shows promise for improving learning.

### **8.5.2 Conclusion**

Together, the findings from this study support show that SMART Note better supports active reading in the tablet textbook environment than existing systems. Several SMART Note features contribute to this, including the fact that SMART Note minimizes interaction mechanics required for annotation, provides more robust annotation functionality, and is designed to better organize and categorize annotations made over multimedia content. Furthermore, these findings combine with prior work outlined in the preceding chapters of this dissertation to advance our understanding of what it means to actively read and study educational material on interactive, multimedia tablet textbooks. Chapter 9 proposes an extension of the Active Reading Framework that begins to consider the unique ways learners must engage in reading and studying to achieve meaningful learning with tablet textbooks.

## **9 A Novel Perspective of Active Reading on Tablet Textbooks**

The final aim for this dissertation is to advance our understanding of active reading by specifically characterizing the learner experience with interactive, multimedia tablet textbooks. To do so, we must first understand the progression of prior characterizations of active reading and be able to identify both shared concepts and diverging themes in earlier descriptions. Adler & Van Doren's Active Reading (1972), Pugh's Responsive Reading (1978), and Adler's (et al.) Work-Related Reading (1998) are three seminal frameworks for understanding the nature of active reading. However, the theoretical thread that ties them together is neither explicit nor linear in the sense that one evolves from another. Likewise, they aren't meant to replace one another. Rather, each represents a different lens through which to examine, understand, and even practice active reading. Thus, any effort to contribute new perspectives of active reading in any context is likely to include facets of these earlier frameworks.

The research reported in this dissertation suggests that contemporary active reading may be more accurately conceptualized as, at least in part, dependent upon the medium or the platform on which it occurs. In other words, the active reading process and the device being used (i.e., desktop computer, tablet device, etc.) are inextricably linked. This represents a fundamental departure from earlier notions of active reading, particularly those presented by Adler and Van Doren (1972) and Pugh (1978) because their characterizations of active reading were primarily focused on printed documents and books. In that traditional print environment, learners generally engage in the physical strategies of active reading (i.e., annotating, reorganizing, cross-referencing, and browsing) with pen and paper in the book or on a separate document. However, computers, tablets, and mobile devices include built-in active reading tools and also invite new active reading strategies as a result of these affordances. Therefore, as we consider how to characterize active reading in the digital age, it may also be helpful to explore novel perspectives on active reading in relation to specific affordances of individual devices. This is not to say that characterizations of active reading for tablets or other digital devices are wholly different than those that were exclusively envisioned for the paper experience. However, digital affordances – i.e., the integration of multimedia

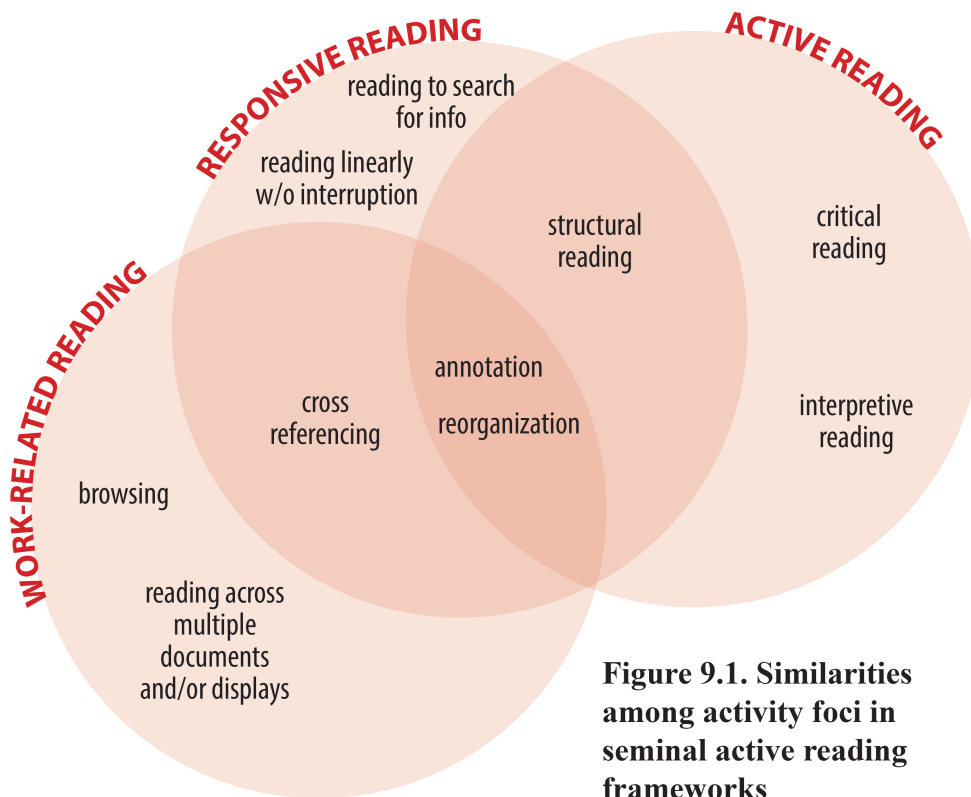


content, touch screen interactivity, and nonlinear presentations, to name a few – clearly have the power to alter the active reading experience in significant ways.

In that spirit, this chapter proposes a novel perspective for understanding active reading called *Multimedia Active Reading on Tablet Textbooks*, a set of characteristics that focuses on the emergent nature of active reading with interactive, multimedia tablet textbooks. *Multimedia Active Reading on Tablet Textbooks* is founded on two key principles. First, it acknowledges the ways in which prior characterizations of active reading inform and contribute to our understanding of active reading on contemporary digital platforms. Second, *Multimedia Active Reading on Tablet Textbooks* is empirically grounded in the research reported in this dissertation, which uncovered ways in which learner behaviors in the tablet textbook environment map to common physical active reading strategies (i.e., annotation, reorganization, browsing, and cross-referencing) and introduced and evaluated novel active reading support designed specifically for the tablet textbook environment. As a result, *Multimedia Active Reading on Tablet Textbooks* extends our understanding of active reading in the 21st Century and articulates three new characterizations of the active reading process.

## **9.1 The progression of Active Reading**

In the 1972 edition of “How to Read a Book,” authors Adler and Van Doren write, “This is a book for readers and for those who wish to become readers. Particularly, it is for readers of books. Even more specifically, it is for those whose main purpose in reading books is to gain increased understanding.” The framework that they outlined then – one that emphasizes the importance of structural, interpretive, and critical reading – remains seminal. Furthermore, it laid the foundation for others to contribute additional characterizations of the physical, cognitive, and purpose-driven tasks associated with active reading for meaningful learning. However, it is worth noting that the kind of texts Adler and Van Doren were talking about represents a fundamentally different structure than that found in contemporary tablet textbooks. For example, Adler and Van Doren focused primarily on practical and theoretical books, imaginative literature, history, and philosophy, to name a few, which were (and to a great extent, still are) dominated by expository text. Furthermore, the three foundational frameworks presented in Chapter 3 –



Active Reading (Adler and Van Doren, 1972), Responsive Reading (Pugh, 1978), and Work-Related Reading (Adler et al., 1998) – clearly converge on a few key themes and diverge on others. On one hand, the strongest areas of overlap exist in similar characterizations of structural reading, a shared commitment to mitigating distraction for effective learning, and the application of physical active reading strategies, such as annotation and reorganization. These overlaps are mapped in Figure 9.1. On the other hand, the frameworks clearly differ when it comes to general focus, with Adler and Van Doren’s Active Reading taking a more author-centric approach, Pugh’s Responsive Reading focusing more on learner goals, and Adler’s (et al.) Work-Related Reading grounded more in technology on which active reading occurs. The following section details these characterizations, as well as articulates the key drivers of the active reading experience that may also point to new directions in characterizing the contemporary active reading experience. Specifically, three interrelated concepts – the textbook structure, level of personal agency during active reading, and the technology on which active reading occurs – represent broader themes in active reading that significantly affect

meaning making. The degree to which each of these themes is emphasized by prior characterizations of active reading varies.

### ***9.1.1 Active Reading: An author-centric approach to meaning making***

Starting with Adler and Van Doren's characterization of Active Reading, we see a clear focus on articulating the different *types* of active reading that primarily point to the learner's responsibility to understand the structure and purpose of a text (structural reading), to grasp the author's arguments and terminology (interpretive reading), and to judge the merit and accuracy of a text (critical reading). Furthermore, while Adler and Van Doren mention the value of outlining and other forms of annotation as a means for organizing one's thoughts about a text, they characterize these physical strategies more as a means to an end than as an integral part of the active reading process. Although the learner is positioned as an obvious player in the pursuit of understanding, Adler and Van Doren effectively place the author and the text at the center of the active reading experience. For Adler and Van Doren, a learner's ability to engage in structural reading – i.e., effectively understanding the textbook structure and the author's intent – is central to the learner's ability to make meaning during the active reading experience.

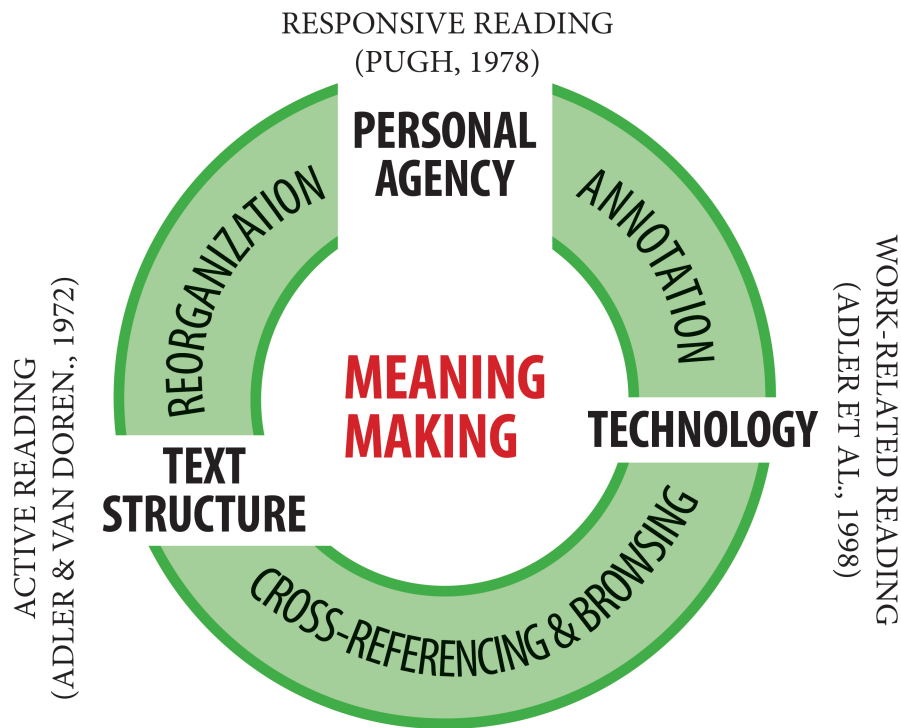
### ***9.1.2 Responsive Reading: An learner-centric approach to meaning making***

Just a few years after "How to Read a Book," Pugh (1978) posited Responsive Reading, a more goal-oriented approach to characterizing the active reading experience, shifting focus to the *reasons* learners engage in active reading. This shift not only highlighted a stronger emphasis on the importance of a learner's personal agency and individual active reading goals, but it also asserted that three main physical strategies – annotating, reorganizing, and cross-referencing – are part and parcel of active reading. Pugh's characterization focused on *why* a learner might engage in active reading, including to understand the general structure of the material, to read linearly without interruption, to search for specific information, to acquire general information, or to annotate, reorganize, or otherwise take notes over the material to help with future recall (p. 137). Pugh's model isn't a complete departure from Adler and Van Doren's Active Reading. For example, Pugh clearly emphasizes the importance of a learner's effort and

ability to understand the structure and purpose of a text, a concept that represents the bulk of Adler and Van Doren's framework. However, for Pugh, structural reading is only part of the equation. The other facets of Responsive Reading are exclusively focused on the learner's goals, emphasizing personal agency as the main driver for meaning making.

### **9.1.3 *Work-Related: A technology-centric approach to meaning making***

Adler and Van Doren's Active Reading and Pugh's Responsive Reading remained the most influential frameworks for more than 20 years, and several commonly used teaching and learning strategies, such as the Survey-Question-Read-Recite-Review (Robinson, 1970) and Know-Want-Learn (Ogle, 1986) methods (detailed in Chapter 3), grew from them. However, in 1998, focus again shifted, this time toward the *technology* with which learners engage during active reading in the then-emerging digital space. With their contribution of Work-Related Reading, Adler et al. (1998) were the first to recognize that in the digital age, learners often read and annotate several documents or digital displays concurrently. This contribution was in no way meant to replace prior work. In fact, Adler et al. cite several activities that, according to their research, play central roles in active reading. These include skimming (or browsing) to establish a rough idea of what information is most useful or important, reading to search for information or ask questions, reading for general knowledge, reading to learn something specific, reading for cross-referencing across documents and displays, and reading to critically review a text (p. 243). Clearly, research on Work-Related Reading affirms Pugh's emphasis on a learner's motivation for active reading. Likewise, Adler et al., also emphasized the important roles that annotation, reorganization, cross-referencing, and browsing play in the active reading process. However, by focusing on the role of technology in the active reading experience, Adler et al. provide a bridge from traditional narrative-text-centric models of active reading to contemporary characterizations that must, at least in part, be defined in terms of the platforms on which active reading occurs. Figure 9.2 illustrates relationships between meaning making and the textbook structure, level of personal agency during active reading, and technology on which active reading occurs, as well as how they map to each of the seminal works on active reading.

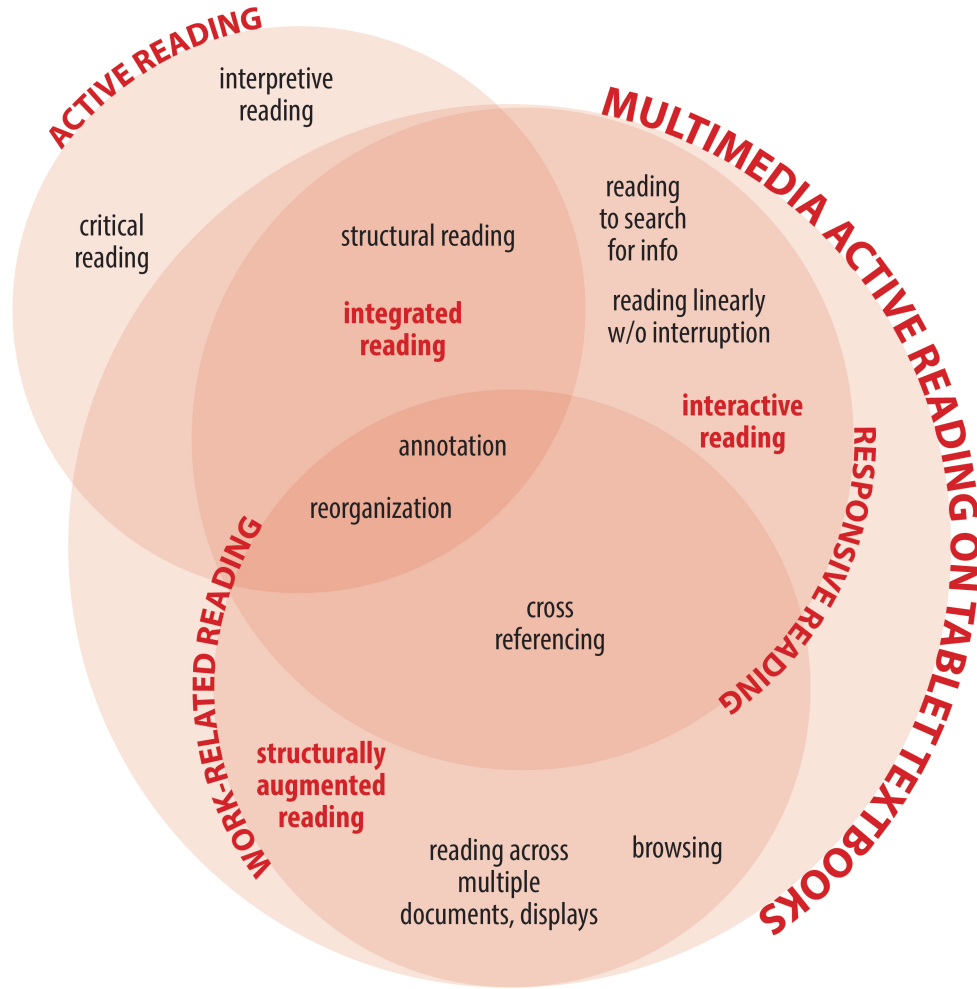


**Figure 9.2. Textbook structure, personal agency, technology, and the physical strategies associated with active reading are interconnected facets of the active reading experience. The degree to which each of these is emphasized by prior characterizations of active reading varies.**

## 9.2 Multimedia Active Reading on Tablet Textbooks

The active reading behaviors and strategies learners exhibit in the interactive, digital space are markedly different than in the traditional print environment, as was evidenced in the tablet textbook studies presented in this dissertation. Of course, digital devices – e.g., desktop computers, eReaders, tablets, mobile phones, etc. – invite different modes of interactivity. For example, touch-screen devices involve different interaction patterns than desktop computers. Likewise, learners engage with narrative text differently than they do with audiovisuals. Thus, the particular affordances and content models offered by a specific platform may directly affect the active reading experience.

Specifically, tablet textbooks introduce three novel facets of content and engagement that fundamentally change the active reading experience. First, complex multimedia, such as audio, video, and interactive information graphics, are integrated with expository text, offering a number of very different presentation and consumption



**Figure 9.3. Multimedia Active Reading on Tablet Textbooks mapped to prior characterizations of active reading**

methods for educational content. Second, a learner's interaction with the tablet textbook changes dramatically, as multimedia content, touch-screen interactivity, and digital annotation mechanics represent a considerable departure from paper page turning and hand-written annotations. Third, the tablet textbook becomes an intelligent agent that automatically reorganizes and concatenates a learner's annotations. Together, these phenomena lay the foundation for characterizations of active reading that consider device-specific affects on learning process and experience. It is also important to note that the physical tasks associated with active reading defined by earlier research (Adler & Van Doren, 1972; Pugh, 1978; Adler et al., 1998) – annotation, reorganization, cross-referencing, and browsing – are still relevant to active reading with tablet textbooks.

Thus, the characterizations of active reading that comprise *Multimedia Active Reading on Tablet Textbooks* are based on (1) the unique affordances offered by tablet textbooks; (2) results from research that suggests existing tablet textbook platforms fall short of providing efficient and effective active reading experiences; and (3) several of the cognitive and physical strategies identified by Adler and Van Doren (1972), Pugh (1978), and Adler et al. (1998) that are still relevant in the tablet textbook environment. The remaining sections of this chapter present three new conceptual approaches to understanding active reading on tablet textbooks: *Interactive Reading*, *Integrated Reading*, and *Structurally Augmented Reading*. Figure 9.3 illustrates how these themes map to prior characterizations of active reading, and the sections that follow elaborate on how each new theme was conceptualized, as well as how each relates to prior work.

### **9.2.1 *Interactive Reading: Balancing mechanical interaction, annotation tasks, and comprehension***

In the tablet textbook environment, learners interact with the mechanical affordances of the device while annotating and studying content. As a result:

*During Interactive Reading, learners try to equally balance mechanical interaction with a device and an uninterrupted focus on reading comprehension.*

“Mechanical interaction” typically refers to the tapping, swiping, and/or similar interaction patterns learners must use to annotate or otherwise interact with content (e.g., tapping and swiping to pause, rewind, and replay a video or engage with an interactive graphic). Alternatively, “uninterrupted focus on reading comprehension,” typically refers to the equally important need for learners to avoid any distractions that would take them out of the flow of careful concentration on the educational material (e.g., minimizing the amount of tapping and swiping necessary to pause, rewind, and replay a video). Of course, the idea that effective active reading experiences must be free from distraction that compromises learning is not new. In fact, prior characterizations of active reading, namely Pugh’s Receptive Reading, are specifically predicated on the notion that learners must be able to read linearly without interruption. Granted, Pugh was specifically

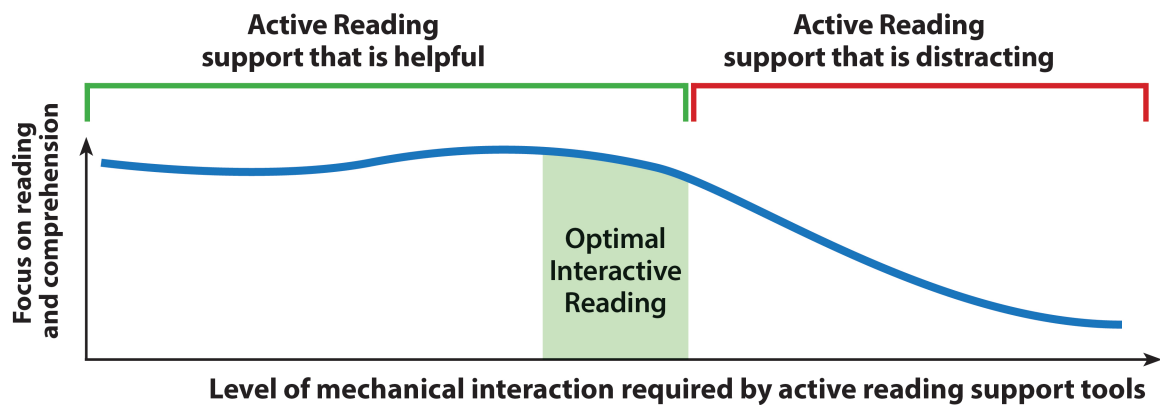
referring to a learner's interaction with expository narrative text, and the types of distraction that may have plagued that experience were mostly environmental in nature (i.e., background noise). However, advancements in technology since 1978 have been vast, and drawing a connection between Pugh's Receptive Reading and *Interactive Reading* on multimedia tablet textbooks is relatively simple. Although platform (i.e., print book vs. tablet book) and content format (i.e., expository text vs. audiovisuals) have changed, the core principle has not: in order to effectively comprehend and retain information, the active reading experience must be free from distraction.

Additionally, a notable duality exists when it comes to mechanical interaction with tablet textbooks, in that interactivity can either be distracting or helpful. One hand, mechanical interaction can keep learners engaged, focused, and interested in the study activity. For example, results from the research outlined in this dissertation showed that learners appreciated and benefited from interactive features that allowed them to easily collect important pieces of information from a chapter for future review. However, mechanical interaction can also introduce a tension between the necessary focus on comprehending content and the required physical activities associated with interactive features, such as tapping and swiping. For example, evidence that learners are often distracted by the mechanics of interactive content was pervasive throughout the studies outlined in this dissertation. Such distractions first surfaced in the preliminary exploratory study through observations and learner feedback. Participants noted that video annotation was particularly complicated because in order to carefully study instructional video, learners had to frequently pause, rewind, fast-forward, and/or replay portions of longer videos to effectively make notes over important information therein. Prolonged or repeated interaction was perceived merely as mechanical overhead that in no way supported active reading, but rather, became potentially distracting and cumbersome. In short, all that time spent tapping, swiping, pausing, rewinding, and re-watching often pulls learners away from focusing on the information.

Unnecessary mechanical interaction with the device can be minimized so that learners have less distraction during active reading, as was evidenced in the final comparative study. In fact, learners responded positively to the efficiency and reduced interaction mechanics facilitated by SMART Note annotation features, namely one-tap



highlighting, key term capture, and video segment capture. Learners noted that these features were “engaging” and encouraged learners to “stay focused on content” and “make better notes than [they] normally would with paper and pencil.” Thus, it stands to reason that mechanical interaction with the device must be minimized as much as possible to mitigate unnecessary distractions and to facilitate optimal *Interactive Reading*, as illustrated in Figure 9.4.



**Figure 9.4. Optimal *Interactive Reading* occurs when distracting mechanical interaction with the device is mitigated as much as possible so that learners can focus effectively on content consumption and learning.**

As a result, tablet textbooks should provide built-in, interactive annotation and study tools that adhere to three main principles:

1. Annotation tools should be aligned to and appropriate for a specific interactive device. For example, SMART Note capitalized on touch screen interaction affordances by implementing a “one-tap” design for many of the key annotation features, such as highlighting, key term capture, and video segment capture.
2. Mechanical interaction that is merely functional overhead should be minimized. By way of example, SMART Note’s “one-tap” options for marking, annotating, and concatenating learners’ annotations also minimized unnecessary interaction patterns, allowing learners to take a greater number of notes over a variety of media formats, with fewer button taps.
3. Interactivity should facilitate engagement and hold attention. This was evident among users who noted that several SMART Note annotation features – such as one-tap highlighting, key term capture, and video segment capture – were more

efficient than tools offered by the Baseline system, which helped them stay more focused on reading and less distracted by system mechanics.

An understanding of *Interactive Reading* is important for theorists and researchers because it characterizes the specific ways in which mechanical interaction is tied to learning outcomes and active reading experience. For tablet textbook designers and authors, *Interactive Reading* highlights the need for annotation features that maximize functional efficiency in order to minimize distraction.

### **9.2.2 *Integrated Reading: Synthesizing and cross-referencing information delivered in multiple media formats***

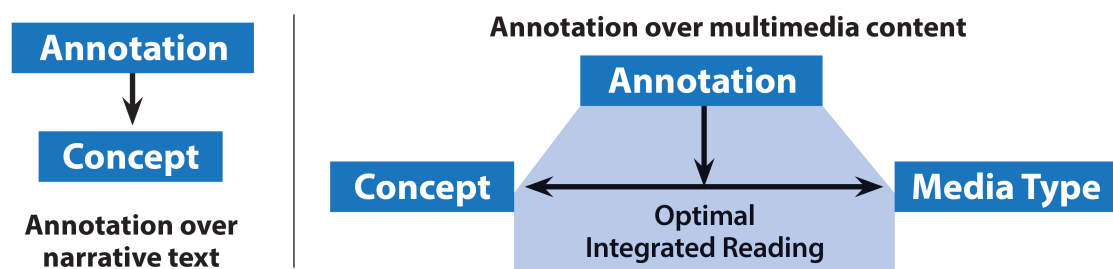
When multimedia content is integrated with narrative text in tablet textbooks, learners need to synthesize information delivered across all media formats. To support active reading across a diverse range of media content, learners must leverage tools that enable them to study video, audio, images, etc. as comprehensively as they do traditional narrative text. As a result:

*During Integrated Reading, learners attempt to conceptually and mechanically make connections between individual annotations and the media sources from which they originated to stimulate memory and recall.*

For example, when a learner reviews an annotation at some point after it was originally made, it may be useful for the learner to be able to quickly recall the media format from which the annotation derived, especially when it comes to multimedia messages. Due to the highly visual nature of video content, for example, memory and understanding may be more quickly stimulated if annotations are marked to indicate their source. Therefore, *Integrated Reading* is also functionally tied to both cross-referencing and browsing, as learners attempt to engage in multimedia synthesis during both of these active reading tasks. Like *Interactive Reading*, *Integrated Reading* has roots in earlier characterizations of active reading, particularly when it comes to assertions that understanding the structure and purpose of a text is critical for effective meaning making. In fact, the bulk of Adler and Van Doren's (1972) framework emphasizes the structural, interpretative, and critical reading as a learner's need to understand the author's intent, arguments, terminology, and

accuracy. Thus, Adler and Van Doren point to a fundamental relationship between learner and author that exists through the structure of the text. Pugh (1978) continued this line of reasoning, placing the emphasis on a learner's desire to read "to get an overview about the general structure" of the material. And Work-Related Reading (Adler et al., 1998), by its very nature, is concerned with structure, as it emphasizes that with the advent of digital technology, active reading often occurs across multiple devices, each of which is governed by its unique structure. We can, therefore, extrapolate notions of structural reading to tablet textbooks that integrate multimedia content through *Integrated Reading*, where structural reading is as much about the need for learners to understand how information is organized in a passive of expository text as it is about understanding how information is organized across multiple media formats.

Furthermore, there exists an internal cross-referencing that occurs during active reading with tablet textbooks that involves more than simply working back and forth between the body of the text and one's annotations. This is especially the case when it comes to multimedia content. Unlike annotating traditional narrative text, which merely involves attaching an annotation to a concept, annotating multimedia content involves a more nuanced relationship between the concept and the media type in which that concept was delivered. Thus, learners may benefit from considering an annotation as attached to both the concept and the media type itself, as illustrated in Figure 9.5.



**Figure 9.5. Annotation over traditional narrative text merely involves attaching an annotation to a concept explained in the chapter (left). However, when information is delivered in multimedia formats, optimal *Integrated Reading* occurs when annotations can be identified as having a relationship to both the concept explained in the chapter and the media type.**

Examples of this were observed during the preliminary study, as learners often marked their notes to indicate the type of media format with which an annotation was

associated (i.e., video or graphic), and then articulated the necessity for this behavior in order to “remember more of the information later.” Furthermore, several learners made sketches on paper while watching videos and animations in an attempt to capture the visual frames in their notes. Again, this behavior is evidence of the need for learners to conceptually synthesize information from multimedia content. This need to mentally map annotations to their sources was also present during browsing activities when learners review and study annotations. In the exploratory study, participants often indicated that it was difficult to make sense of the concatenated list of annotations because they were not meaningfully organized. Similar comments were also made during the comparative study, as many Baseline participants indicated that the long list of annotations in the Baseline annotation notebook lacked any “logical order” and seemed like a “big list of thrown together.”

To mitigate this issue, tablet textbooks must be designed to support learners in their efforts to easily browse and cross-reference annotations to related media sources by adhering to two main principles:

1. Complexity introduced by multimedia presentations should be leveraged to stimulate memory. For example, SMART Note’s video transcript annotation – by far the most favorable and widely used video annotation feature – provided learners with a concrete reference point for the video, which helped mitigate the transient nature of audiovisuals. Thus, video transcript annotation represented a strong method for internally cross-referencing information provided in videos.
2. Visual cues and categorical organization of annotations should be used to stimulate memory and facilitate orientation and/or recall. The SMART Note design implemented visual cues, such as color-coding and icons, to help identify the media format from which an annotation originated. Thus, when learners view all of their annotations in one concatenated list, these visual cues are prominent ways of indicating from where each note was derived, e.g. from a video, image, narrative text, or interactive graphic. Furthermore, as learners make annotations, the system automatically tags, classifies, and organizes them according to media type. This way, the learner can later filter and browse annotations categorically, which may stimulate better mental organization, memory, and recall. In fact,

during the final comparative study, several participants indicated that filtering by media type helped them “stay mentally organized” and “remember information from the videos” better than browsing one long list of annotations.

An understanding of *Integrated Reading* is important for theorists and researchers because it illustrates a learner’s need to stay mentally organized by recalling media formats to combat complexities introduced by multimedia presentations and characterizes the relationships between multimedia annotations, presentation and recall. For tablet textbook designers and authors, *Integrated Reading* highlights the need for aesthetic *and* organizational features that stimulate memory.

### ***9.2.3 Structurally Augmented Reading: Capitalizing on the potential for automatic reorganization to support easy browsing, while preserving the value of personalization***

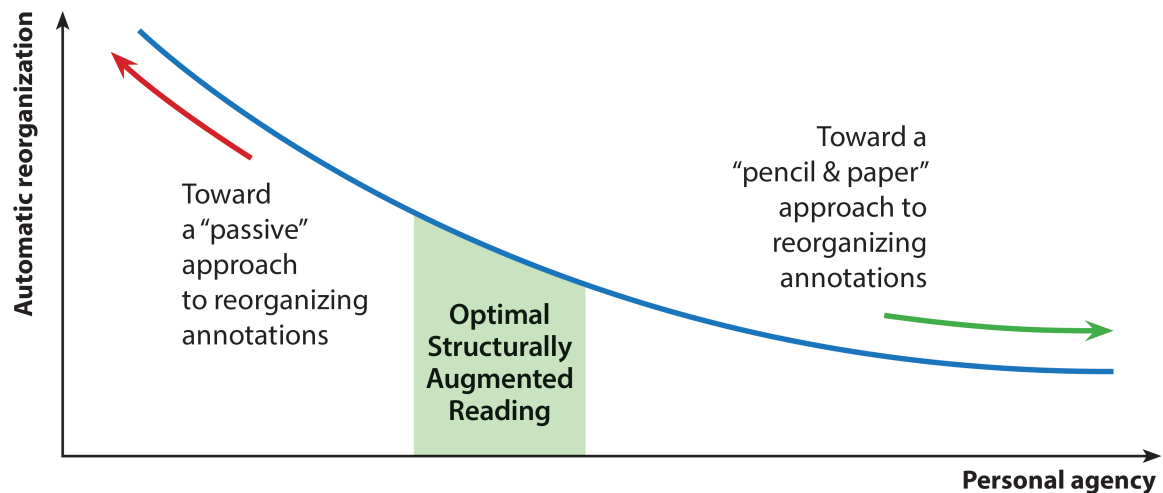
During active reading, learners must organize their annotations and notes in personally meaningful ways; and most tablet textbooks provide some level of automatic reorganization that is materialized in a concatenated collection of annotations. For example, in platforms like Inkling, iBooks Author, and the like, highlighted text and/or a learner’s notes over the reading material appear in an annotation notebook that is accessible with the tap of a button. Thus, an effective tool must support meaningful browsing of annotations by anticipating organizational schemas that learners find intuitive. Furthermore, tablet textbooks should provide a structured view of annotations that can be used to do more open-ended, personalized note making on paper. In other words, meaningful organizational structures can serve as pre-scaffolding for paper notes made after initial annotations have been collected in one place. As a result:

*During Structurally Augmented Reading learners take advantage of automated reorganization tools to augment their usual study habits.*

For example, a learner might use the tablet textbook annotation notebook as a means for collecting and organizing all of their annotations in one place. However, a particularly adept active reader may go on to create an even more personalized representation of those annotations in the form of a pencil and paper outline, flashcards, or similarly crafted

artifact. In this sense, the tablet tools serve as scaffolding that supports a first-level set of collection and organizational aids to mediate additional study habits. Again, this concept can be traced back to earlier work. Specifically, Structurally Augmented Reading is strongly tied to Work-Related Reading (Adler et al., 1998), which at its core is about recognizing that active reading is strongly influenced and driven by activities that may happen outside of the book (i.e., annotation, reorganization, cross-referencing, and browsing) and reading *and* studying activities are often performed across multiple artifacts (i.e., printed books, computers, and paper and pencil). Additionally, Work-Related Reading place annotation, reorganization, cross-referencing, and browsing at the center of the active reading experience, while earlier work places them in a subordinate or supportive role to meaning making and structural understanding. This is likely, in part, because digital technologies, such as tablet textbooks, make way for built-in active reading support tools, while traditional print books require that learner's bring additional tools (e.g., pencil, paper, note cards, etc.) to the active reading experience.

However it is also important to note that although automatic reorganization has the potential to introduce new levels of efficiency, systems that automate tasks also have the potential to eliminate significant personal agency, as illustrated in Figure 9.6. For example, during their interaction with SMART Note, several participants noted that although they liked the ease with which they could save key terms and definitions with just one tap, they were also concerned that collecting definitions in this manner may actually be *too* easy. According to one participant, "I need to write the definitions in my own words to remember them. Actually writing them like that is part of studying for me. It helps me remember them better" [P13]. Viewed from this perspective, the very physical nature of many active reading tasks – e.g., "writing information in my own words"; making outlines, lists, flash cards, and other artifacts; and highlighting or otherwise marking a text – is often inextricably linked with memory and recall. In other words, manually building a personalized representation of one's annotation is, in its own right, a form of active reading. Thus, *Structurally Augmented Reading* urges us to consider active reading tools provided by tablet textbooks as mechanisms for *enhancing* active reading as opposed to *replacing* the still-valuable tools that are pencil and paper. For example, learners might consider annotating in the tablet environment as the first step



**Figure 9.6. Active reading support in the tablet environment need not replace pencil and paper approaches to annotation, which can carry with them a strong sense of personal agency when it comes to a learner’s ability to make personally meaningful study aids. Thus, *Structurally Augmented Reading* is best supported by tablet textbooks that provide automated reorganization tools that help learners create a first-level structure for their annotations that can later be used to create additional personalized artifacts and study aids.**

to studying that allows them to quickly gather the most important information from a chapter in one place. SMART Note allows learners to do this with easy-to-use, efficient annotation tools that allow learners to build a Concept Map Study guide that is equally user-friendly and robust. Then, a particularly adept active reader could use that Concept Map Study guide as scaffolding for further organizing annotations with pencil and paper in any way that is personally meaningful.

Thus, tablet textbook designs should consider two main principles:

1. Reorganization tools should be designed to anticipate structural schemas and organizational cues that are intuitive and useful to learners. SMART Note addressed this requirement by providing the Concept Map Study Guide, a highly visual annotation notebook that includes three different ways for learners to view annotations. First, the Concept Map Study Guide provides *visual list view*, which is a concatenated list of all annotations color-coded and marked with icons to denote media type. List view also encourages learners to filter annotations according to media type. Second, the Concept Map Study Guide provides *map view*, which is an interactive schematic/outline of annotations organized according

to section headings that correspond with the main sub-sections of a chapter. Map view is designed to emulate an outline that follows the structure of the textbook chapter and identifies where in each section annotations have been made. These design alternatives make use of organizational schemas that are already familiar to learners and therefore, invite multiple approaches to accessing that material.

2. Learners should be encouraged to also work outside of the system to build personally meaningful study aids in concert with those built into the tablet textbook system. This requirement was not inherently part of the SMART Note design. Additionally, the comparative study design specifically prohibited participants from annotating outside of the tablet environment. This decision was initially made to limit the number of variables that could affect learners' perceptions of workload and active reading experience. However, the decision also serendipitously served another important purpose. Prohibiting annotation outside of the tablet environment inadvertently prompted user feedback about the value of pencil and paper annotation, as well as the limitations to personal agency when pencil and paper are disallowed. The fact that several SMART Note participants indicated a desire to use *both* SMART Note and pencil and paper notes to build personally meaningful study guides indicates that the presence of automated features may provide learners with more time to devote to active reading strategies both in and outside of the textbook environment.

An understanding of *Structurally Augmented Reading* is important for theorists and researchers because it illustrates the important balance between the efficiency of automated reorganization and the significance of personal agency for effective active reading experience. For tablet textbook designers and authors, *Structurally Augmented Reading* highlights the need for automated annotation and review features as well as systems that encourage and support personalization for meaningful learning.

Certainly, there are an uncountable number of design solutions that would achieve the requirements set forth for *Interactive Reading*, *Integrated Reading*, and *Structurally Augmented Reading*. As such, all of the requirements outlined above can be viewed as a set of guiding principles for designers as they see to develop additional design



contributions for future systems. Table 9.1 revisits prior characterizations of active reading with the addition of Multimedia Active Reading on Tablet Textbooks.

Model	Key Characteristics	Physical Strategies
<b>Multimedia Active Reading on Tablet Textbooks</b>	<b>Interactive Reading:</b> Balancing balance mechanical interaction with a device and an uninterrupted focus on reading comprehension. <b>Integrated Reading:</b> Cognitively connecting annotations to media sources to stimulate recall <b>Structurally Augmented Reading:</b> Taking advantage of reorganization tools to maximize efficiency, augment traditional study habits	<ul style="list-style-type: none"> <li>• Annotation</li> <li>• Reorganization</li> <li>• Cross-referencing</li> <li>• Browsing</li> </ul>
<b>Active Reading</b> (Adler & Van Doren, 1972)	<b>Structural reading:</b> Understand the structure and purpose of a text <b>Interpretative reading:</b> Understand author's arguments, special phrases, terms <b>Critical reading:</b> Judge the merit and accuracy of a text	<ul style="list-style-type: none"> <li>• Note making</li> <li>• Outlining (reorganizing)</li> <li>• Cross-referencing</li> </ul>
<b>Responsive Reading</b> (Pugh, 1978)	<b>Linearly progressing</b> through the text without interruption (i.e., receptive reading) <b>Reading to search</b> for a specific piece of information <b>Reading to acquire</b> information without a set goal <b>Reading to get an overview</b> about the general structure of the material	<ul style="list-style-type: none"> <li>• Annotation</li> <li>• Cross-referencing</li> <li>• Reorganizing</li> </ul>
<b>Work-Related Reading</b> (Adler, Gujar, Harrison, O'Hara, & Sellen, 1998)	Reading that happens more frequently with writing than without and is performed across several documents or displays concurrently	<ul style="list-style-type: none"> <li>• Annotation</li> <li>• Browsing</li> <li>• Cross-referencing</li> </ul>

**Table 9.1. Prior characterizations of active reading with the addition of Multimedia Active Reading on Tablet Textbooks**

### 9.3 Significance of contribution to HCI

*Multimedia Active Reading on Tablet Textbooks* focuses specifically on the key characteristics of active reading with textbooks on interactive, multimedia, touch screen

tablet devices. This model is both an extension to prior efforts to characterize active reading, as well as a framework for better understanding the most significant challenges, tensions, and shortcomings learners face when annotating and studying educational material in the tablet textbook environment. Thus, the significance of this contribution is twofold:

First, Multimedia Active Reading on Tablet Textbooks provides active reading scholars with a framework for better understanding what it means to study in the tablet textbook environment that is both grounded in active reading theory and based on learner behaviors, preferences, and performances in natural study sessions. The use of iPad, Android, and other tablet devices continues to become more prevalent in educational settings, and tablet textbook development is increasing. Thus, the Multimedia Active Reading model helps us better understand how the affordances of tablet devices may lead to unique user experiences and learning scenarios. Furthermore, this extension to the Active Reading framework asserts that contemporary notions of active reading must consider how individual technologies affect the active reading process.

Second, this new model characterizes how specific interaction patterns and design affordances for tablet textbooks affect active reading. In this regard, Multimedia Active Reading can also serve as a set of guidelines for tablet textbook authors, designers, developers, and publishers who wish to provide learners with unique, engaging, and effective learning experiences. SMART Note, therefore, represents the reification of one set of design solutions meant to address active reading in the tablet textbook environment. Furthermore, when it comes to the locus of meaning making, SMART Note strikes a more equal balance regarding the emphasis of authorial intent, learner goals, and technological affordances than prior active reading frameworks. First, from the textbook author's perspective, SMART Note provides a structure that leverages the rich potential of integrated multimedia and built-in active reading support in the delivery of educational content. For example, video segment capture not only allows the learner to mark and save portions of video in meaningful ways, but it also allows the author to produce video content that is conceptualized specifically a segmented approach to annotating that video. In doing so, the author may begin to reconsider how to structure an individual video clip that plays to the strengths of the SMART Note annotation system. Second, from the

perspective an individual reader's sense of personal agency, SMART Note provides learners with more robust annotation and reorganization tools, as well as enhanced design mechanisms intended to help them better comprehend and remember information. Third, from the perspective of the technological apparatus, SMART Note is designed with a specific type of digital device in mind in an effort to recognize that the affordances offered by tablet devices may lead to unique user experiences and learning scenarios. Although SMART Note is only one of many possible approaches to novel active reading support, the SMART Note system provides an opportunity to test design solutions intended to improve active reading in the tablet textbook environment.

## 10 General Discussion and Conclusion

The primary goal for this dissertation was to better understand the nature of active reading and learning in the interactive, multimedia tablet textbook environment. This research is necessary for three reasons:

First, the tablet has evolved as a teaching and learning technology in its own right, one that blends features of laptops, smartphones, and earlier eReaders with always-connected Internet, rich multimedia potential, and built-in annotation and study aids. Furthermore, since the 2010 introduction of the iPad, the tablet has become independent and distinct from other mobile devices. However, although adoption in educational settings has been rapid and innovations in interactive, multimedia tablet textbooks have continued to emerge, more empirical scrutiny regarding how tablet textbooks support and engender active reading is necessary. This dissertation has demonstrated that active reading and tablet textbook functionality are inextricably linked, as integrated multimedia, as well as the types of annotation features tablet textbooks provide, affect the ways in which learners interact with, consume, and study educational content.

Second, this research identifies deficiencies in active reading support among existing tablet textbook platforms and suggests new annotation features and design structures to address shortcomings. While SMART Note represents a novel contribution to tablet textbook design, it also provides an opportunity to further evaluate how learners effectively *study* in the multimedia tablet textbook environment. The answer to this question is important to a wide variety of audiences including digital book publishers, educators, textbook authors and designers, and students themselves because active reading is, indeed, essential for meaningful learning. Thus, tools designed to support the physical tasks most commonly associated with active reading must align with both the natural affordances of the device *and* learners' goals for reading and studying.

Third, this research paves the way for a better characterization of tablet textbook active reading. Specifically, new characterizations of active reading offered in this dissertation recognize the tension between active reading and mechanical interaction; advocate for designs that facilitate cognitive connections between annotations and media formats; and encourage opportunities for learners to personalize annotations as a meaningful way to reorganize the learning material.

	AIM ONE	AIM TWO	AIM THREE
TASKS	<p>Identify learners' active reading behaviors when engaged with a tablet textbook</p> <ol style="list-style-type: none"> <li>1. Develop two tablet textbook chapters for implementation in exploratory study of learner behaviors</li> <li>2. Engage in qualitative analysis of key actions learners take during natural study session with tablet textbooks</li> <li>3. Envision key requirements for novel features grounded in relevant theories of active reading and multimedia learning</li> </ol>	<p>Introduce, evaluate novel tools that support active reading of audiovisuals in the tablet environment</p> <ol style="list-style-type: none"> <li>1. Conceptualize SMART Note, a suite of novel annotation features for tablet textbooks</li> <li>2. Iteratively design, develop, and test SMART Note prototypes</li> <li>3. Evaluate SMART Note efficiency compared to Inkling Habitat</li> <li>4. Develop, validate Active Reading Experience Questionnaire to assess active reading experience</li> <li>5. Empirically investigate learning experience, process, and outcomes associated with SMART Note compared to existing tablet textbooks</li> </ol>	<p>Extend Active Reading framework to include behaviors that emerge in tablet textbook space</p> <ol style="list-style-type: none"> <li>1. Extend the Active Reading framework so that it more accurately characterizes the learner experience with interactive, multimedia tablet textbooks</li> </ol>
CONTRIBUTIONS	<p>First work to identify key active reading behaviors learners enact in the tablet textbook environment</p>	<p>Introduces the AREQ, a new tool for assessing active reading experience</p> <p>novel and empirically validated active reading features for audiovisuals and text that outperformed existing tablet textbook annotation features on efficiency and learning experience, process, and</p>	<p>First work to articulate an extension of the active reading framework that better captures the activities and behaviors of learners in the tablet textbook environment.</p>

**Figure 10.1. Revisiting the aims that guided this dissertation**

Figure 10.1 revisits the aims that guided this dissertation and aligns them with key research tasks and the resulting contributions.

### **10.1 Research questions revisited**

The first research question for this study was to explore what active reading and learning strategies learners employ when presented with an interactive, multimedia tablet textbook. In order to answer this question, a preliminary study was conducted with 30 undergraduate students (aged 18-20; 12 male, 18 female) at Ball State University. Four key behaviors were identified as a result of the analysis of observational data and artifacts generated during study sessions: 1) sketching video frames, 2) recalling animation mechanics rather than accurate content, 3) integrating concepts embedded in multimedia with notes drawn from other sources, and 4) struggling with the tension between operating audiovisual content and the active reading experience. Additionally, results indicated that existing active reading tools do little to support learners when they struggle to make sense of and subsequently remember content delivered in multiple media formats, are distracted by the mechanics of interactive content, and grapple with the transient nature of audiovisual material.

The second research question was to discover what types of tools must be developed for users to achieve their active reading and learning goals in the multimedia textbook. In order to answer this question, a suite of novel multimedia annotation tools for tablet textbooks was iteratively designed, developed, and tested with users at three stages of fidelity. SMART Note integrates traditional narrative text with interactive, multimedia content and provides learners with efficient, one-tap options for marking, annotating, and concatenating their annotations. Findings from early usability sessions helped improve the SMART Note design so that later tests were met with no significant usability issues.

The third research question was to determine how novel active reading strategies and features manifest in the proposed SMART Note system compare to the active reading strategies and features provided by leading tablet textbook platforms currently on the market when it comes to usability, efficiency, active reading experience, and learning outcomes. To answer this question, several studies were conducted that compared

<b>Research Question</b>	<b>Answer</b>
<b>Q1:</b> What active reading and learning strategies do learners employ when presented with an interactive, multimedia tablet textbook?	Four key behaviors emerge when learners read study tablet textbooks: 1) sketching video frames, 2) recalling animation mechanics rather than accurate content, 3) integrating concepts embedded in multimedia with notes drawn from other sources, and 4) struggling with the tension between operating audiovisual content and active reading. Learners also struggle to make sense of remember content delivered in multiple media formats, are distracted by the mechanics of interactive content, and grapple with transient audiovisuals.
<b>Q2:</b> What types of tools must be developed for users to achieve all of their active reading and learning goals in the multimedia textbook environment?	Effective tablet textbooks should minimize mechanical interaction with the device, provide concrete ways for learners to access important information presented in audiovisuals, and improve the organization of annotations so learners are more easily able to recall the original source format (i.e., audio, video, text, etc.) of an individual note and make conceptual connections among notes that have been combined into a study guide.
<b>Q3:</b> How do novel active reading strategies and features proposed in the SMART Note system compare to the active reading strategies and features provided by leading tablet textbook platforms currently on the market when it comes to usability, efficiency, active reading experience, and learning outcomes?	SMART Note is more efficient, easier to use, and provides a better overall active reading experience than tablet textbook platforms currently on the market. Furthermore, for this particular study, SMART Note yielded higher quiz scores, more engagement, and a greater number of annotations than the alternative system.
<b>Q4:</b> How should our understanding of active reading evolve to include behaviors that emerge when learners engage with educational materials in tablet textbooks?	The proposed model for Multimedia Active Reading on Tablet Textbooks proposes Interactive, Integrated, and Structurally Augmented reading to better characterize what happens when learners engage in active reading in the tablet textbook environment.

**Table 10.1. Synopsis of research questions and answers**

SMART Note to a Baseline prototype that represented annotation and study features present in Inkling Habitat, the leading tablet textbook platform currently on the market. Part of this research also included the development of the Active Reading Experience

Questionnaire (AREQ), a new instrument for assessing active reading experience. Ultimately, SMART Note outperformed the Baseline prototype on efficiency, usability, active reading experience, perceived cognitive load, and learning process and outcomes.

Finally, the fourth research question focused on determining how the current active reading framework should evolve to include behaviors that emerge when learners engage with educational materials in the digital space. To answer this question, results from all of the research conducted was used to reflect on how the active reading framework should evolve to better characterize what it means to carefully read and study educational material in the digital space. A synopsis of the three research questions and their answers is given in Table 10.1.

## **10.2 Limitations**

Every effort was made to ensure that the data collected for this dissertation was a reliable and valid reflection of the individuals who participated in the research studies. Some limitations exist, however, related to the extent to which these results can be generalized. First, a limited sample size was available for the exploratory study (30 participants total, 15 in each condition). The limited sample size was due, in large part, to the relative lengthiness of the study design (approximately 90 minutes per participant, one-on-one with the researcher). However, it is not uncommon for contextual inquiry and similar types of observational research to include smaller samples. And although results are generally inadequate for conducting statistical inference, such studies are quite useful for gaining insights into behavior that can then be used to drive new design solutions for interactive systems (Beyer & Holtzblatt, 1995).

With respect to the participants, the second limitation of this dissertation is the population from which the sample participants were drawn. For all of the studies, undergraduate students from Ball State University were recruited from a few different sample pools. Although every effort was made to ensure that participants for each study were similar demographically and in terms of their prior knowledge of subject matter and previous tablet textbook experience, some variation in those characteristics was inevitable. Such variations – particularly those related to differences in prior experience



with tablet textbooks, active reading acumen, and prior knowledge of subject matter (i.e., photosynthesis) – could affect learning experience, processes, and outcomes.

Finally, perhaps the most significant limitation of this dissertation lies in the fact that only one topic – photosynthesis – was built into the SMART Note design. Clearly some types of content may be more conducive than others for integrated multimedia presentations. And subject matter alone could affect a student’s perceptions of the tablet textbook experience. Thus, these results cannot be generalized to all possible subject matter for tablet textbooks. For example, subjects like color theory and biology lend themselves well to animation and visualization, while other subjects, such as English or Math may not. Furthermore, given different subject matter, new annotation features that are specific to a certain kind of content may emerge. SMART Note features will need to be tested and evolved in order to be applicable in a greater variety of topical areas. Thus, these limitations are discussed here in order to bring awareness to the fact that using SMART Note in other scenarios might yield different results.

### **10.3 Future research directions**

Certainly, there are an uncountable number of design solutions that could potentially improve active reading support in tablet textbook environments. Thus, one very broad direction for future research would be to continue to efforts to identify novel active reading behaviors and related design solutions for tablet textbooks. However, a few more specific directions also exist.

#### ***10.3.1 Testing and evolving the SMART Note design in other subject domains***

If SMART Note were applied to new subject domains – for example, history, art, or anthropology – two potential areas of interest may arise. First, additional exploratory studies are possible as a means for identifying new active reading behaviors that emerge when content is delivered in integrated multimedia presentations. Second, additional annotation features, design strategies, and/or organizational schemas may be identified as a result of these new behavioral discoveries. Likewise, new features may emerge that are more relevant to some types of subject matter content than others. Thus, evolving the SMART Note design is dependent upon expanding the range of topics and subject matter

to which it is applied. Continued research of this kind is important for ensuring that SMART Note is as robust as it needs to be across a multitude of content domains. Additionally, this research is important as we continue to explore what it means to actively study in the emerging tablet textbook environment.

### ***10.3.2 Expanding study of active reading to other types of digital textbook platforms***

Although this dissertation specifically focuses on tablet textbooks, an individual textbook is rarely designed for reading on a single device. Thus, a truly comprehensive active reading system would adapt active reading features for an individual textbook across several different devices, from tablets, to desktop computers, and the like. In light of this, future work might explore how the SMART Note system can be adapted across a variety of platforms that provide integrated multimedia content. Such research would not only ensure that SMART Note can be applied to a single textbook across multiple platforms, but it may also uncover new behaviors and challenges for learners engaged in multimedia active reading on other devices.

## **10.4 Closing remarks**

This dissertation highlights three novel contributions to the field active reading. First, it identifies several key active reading behaviors learners enact in the tablet textbook environment. Second, it introduces novel and empirically validated active reading features for audiovisuals and text that outperformed existing tablet textbook annotation features on efficiency and learning experience, process, and outcomes. Finally, this dissertation articulates an extension to the active reading framework that better captures the activities and behaviors of learners in the tablet textbook environment. It is my hope that this work contributes a strong foundation for better understanding what it means to actively read and study a textbook in the digital age.

## **11 Appendices**

### **11.1 Appendix A: Behavioral study protocol**

#### ***11.1.1 Demographic survey***

**Gender:** M F

**Age:**

**Year in School** Freshman Sophomore Junior Senior

**Do you own a tablet eReader (i.e., iPad, Kindle Fire, Nook, etc.)?** Y N

If yes, what kind of tablet do you own?

**Have you ever read a textbook on a tablet device?** Y N

If yes, what subject(s) did the book(s) cover?

**About how many hours/day do you spend reading textbooks?**

**Which active reading strategies do you regularly use when you read textbooks?**

(Check all that apply)

- ☐ Highlighting key words or phrases
- ☐ Highlighting full sentences
- ☐ Highlighting full paragraphs
- ☐ Writing notes in the margins
- ☐ Outlining key sections or chapters on notebook paper
- ☐ Outlining key sections or chapters on your computer or other digital device
- ☐ Writing notes on post-its or sticky notes
- ☐ Writing notes/outlines of key content on index cards

#### ***11.1.2 Short answer quizzes***

##### ***11.1.2.1 Color theory***

1. Explain what a prism and how color is produced for the naked eye.
2. Explain how color is reproduced for printed materials and digital screens.
3. List and define all of the different color schemes you can recall.
4. List and define the different types of color contrast.
5. Explain the significance of the psychological implications of color.

#### *11.1.2.2 Photosynthesis*

1. Explain the process of photosynthesis.
2. Explain the process of chemical conversion.
3. Explain the carbon cycle.
4. Explain how the nature of light factors into the photosynthetic process.
5. Explain how and why leaves change color.

#### *11.1.3 Semi-structured interview questions*

1. Overall, how would you describe your experience with the color theory chapter?
2. Did you find the material easy or difficult to study? Please explain.
3. Was the color theory chapter easy to use and navigate? Please explain.
4. At any point did you feel confused by the interface? If yes, how so?
5. At any point did you feel frustrated by the interface? If yes, how so?
6. What did you think of the video content you encountered?
7. What did you think of the interactive galleries you encountered?
8. What did you think of the audio files you encountered?
9. Did interactivity help or hinder your study session? How so?
10. What methods did you use to annotate text-based portions of the chapter?
11. What do you think about the inability to annotate multimedia content, such as video, image galleries or audio content?
12. Were there sections of audio or video that you wished you could have annotated?  
If yes, which ones?
13. Describe how you think you would study a video segment.
14. Describe how you think you would study an interactive image gallery.
15. Describe how you think you would study an audio segment.
16. Are there annotation features you would like to use to study video, audio or image galleries that you haven't already mentioned?
17. Do you feel your ability to study was helped or hindered on the tablet? How so?
18. If given the opportunity in the future, would you prefer multimedia textbooks on your tablet like the one you used today over traditional print textbooks? Why?
19. If given the opportunity, would you prefer multimedia textbook on your tablet?
20. Is there anything else you would like to tell me about your experience today?

## 11.2 Appendix B: SMART Note and Baseline prototype screen shots

### 11.2.1 SMART Note screen shots

PHOTOSYNTHESIS

The lifeblood of human existence

**The Cycle of Life**

Photosynthesis is the most important biological process on Earth because it is the foundation of all life forms. In fact, the photosynthetic process serves as the world's largest solar battery, the sun, in short, plants and bacteria use the energy that comes from the sun to recycle the carbon dioxide we exhale into the oxygen we breathe. However, don't be fooled. Photosynthesis is a more complex chemical process than first meets the eye.

The term photosynthesis literally means building up or assembly by light. Not a day goes by without this important process present in the atmosphere around us. All of our food and fuels are created through photosynthesis, and some fuels we use today were actually part of photosynthesis hundreds of years before they came to our use. All forms of life require energy to sustain and grow. Plants capture this energy directly from the sun's rays, while animals must obtain the energy they need by eating plants or other animals that have eaten plants. Thus, the ultimate source of all metabolic energy in our planet is the sun, and photosynthesis is essential for maintaining all forms of life on Earth.

Plants and bacteria use the energy that comes from the sun to produce sugar, which is then converted into adenosine triphosphate (ATP) through a secondary process, called cellular respiration. Through this process, photosynthesis converts massive amounts of sunlight into electrical and then chemical energy. The input is carbon dioxide (CO<sub>2</sub>), water (H<sub>2</sub>O), and sunlight. The output is glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>) and oxygen (O<sub>2</sub>).

TRANSCRIPT

**Photosynthetic Equation**

When humans exhale, they release carbon dioxide into the environment. The CO<sub>2</sub> is absorbed by chloroplasts in plants and combined with water to produce oxygen and glucose.

The plant uses most of the glucose as energy, while most of the oxygen is released into the atmosphere.

Plants and animals absorb this oxygen when they breathe. Through the process of respiration, the carbon cycle begins again.

**Carbon Cycle**

Carbon dioxide and water are taken in as food for plants. When plants absorb sunlight, the carbon dioxide and water molecules are converted into carbohydrates.

These glucose particles and oxygen molecules are then used as energy sources.

The oxygen is released by the plants into the atmosphere, providing humans and animals with the basis for respiration.

**Carbon Dioxide (CO<sub>2</sub>)**

A colorless, odorless gas present in the atmosphere and formed when people exhale during respiration.

**Carbon Cycle**

Interactive: The Body of a Plant

The plant body is divided into several organs: roots, stems and leaves. The leaves are the primary photosynthetic organs of plants, serving as key sites where energy from light is converted into chemical energy. Similar to the other organs of a plant, a leaf is comprised of three basic tissue systems, including the dermal, vascular, and ground tissue systems. Tap the names to learn more about the parts of a leaf.

**The Lives of Leaves**

**Leaf Structures**

Plants are the only photosynthetic organisms to have leaves. A leaf may be viewed as a solar collector crammed full of photosynthetic cells. The raw materials of photosynthesis, water and carbon dioxide, enter the cells of the leaf, and the products of photosynthesis, sugar and oxygen, exit.

Slideshow: Why Leaves Change Color

Leaves contain pigments with potential to produce an endless array of colors, but because of the tree's necessity to make its own nutrients, they are not seen until autumn. Swipe left to see the process of color change in leaves.

**Why Leaves Change Color**

Plants absorb light primarily through the pigment chlorophyll, which is the reason that most plants have a green color. Besides chlorophyll, plants also use other pigments resulting in a wide variety of colors. These pigments are embedded in plants and algae in special antennae proteins. In such proteins all the pigments are ordered to work well together. Such a protein is also called a light-harvesting complex.

During winter, there is not enough light or water for photosynthesis. The trees will rest, and live off the food they stored during the summer. They begin to shut down their food-making factories. The green chlorophyll disappears from the leaves. As the bright green fades away, we begin to see yellow and orange colors. Small amounts of these colors have been in the leaves all along. We just can't see them in the summer because the green chlorophyll conceals them. The bright reds

ALL ANNOTATIONS

CHAPTER 3 | PHOTOSYNTHESIS

**Video: Photosynthetic Equation - (00:09)**

This is a note over the video.

**Key Term: Thylakoids**

A membrane-bound compartment inside chloroplasts and cyanobacteria. They are the site of the light-dependent reactions of photosynthesis.

**Video: Photosynthetic Equation**

**Key Term: Glucose**

Glucose as produced by green plants during the photosynthesis process is used as the main source of energy for a plant and also as a metabolic intermediate. Glucose is first turned into starch for it to be used as an energy store.

**Video: Photosynthetic Equation - (00:35)**

This is another video note.

**Xylem**

Xylem is one of the two types of transport tissue in vascular plants (phloem is the other). The best-known xylem tissue is wood, though it is found throughout the plant. Its basic function is to transport water, but it also transports some nutrients.

**Stoma/Stomata**

The Stoma is a pore found in the epidermis of leaves that includes stems and other organs used to control gas exchange. The pore is bordered by a pair of specialized cells known as guard cells that are responsible for regulating the size of the opening. Air containing carbon dioxide and oxygen enters the plant through these openings and is used in photosynthesis.

**A leaf may be viewed as a solar collector crammed full of photosynthetic cells.**

ANNOTATION MAP

CHAPTER 3 | PHOTOSYNTHESIS

Chemical Conversion

The Carbon Cycle

THE CYCLE OF LIFE

Leaf Structures

Membranes & Organelles

VIDEO: PHOTOSYNTHESIS

Transcript

WHY LEAVES CHANGE COLOR

Why Leaves Change Color

LIGHT & THE PHOTOSYNTHETIC PROCESS

The Nature of Light

### 11.2.2 Baseline prototype screen shots

PHOTOSYNTHESIS

The lifeblood of human existence

**The Cycle of Life**

Photosynthesis is the most important biological process on Earth because it is the foundation of all life forms. In fact, the photosynthetic process serves as the world's largest solar battery, the sun, in short, plants and bacteria use the energy that comes from the sun to recycle the carbon dioxide we exhale into the oxygen we breathe. However, don't be fooled. Photosynthesis is a more complex chemical process than first meets the eye.

The term photosynthesis literally means building up or assembly by light. Not a day goes by without this important process present in the atmosphere around us. All of our food and fuels are created through photosynthesis, and some fuels we use today were actually part of photosynthesis hundreds of years before they came to our use. All forms of life require energy to sustain and grow. Plants capture this energy directly from the sun's rays, while animals must obtain the energy they need by eating plants or other animals that have eaten plants. Thus, the ultimate source of all metabolic energy in our planet is the sun, and photosynthesis is essential for maintaining all forms of life on Earth.

Plants and bacteria use the energy that comes from the sun to produce sugar, which is then converted into adenosine triphosphate (ATP) through a secondary process, called cellular respiration. Through this process, photosynthesis converts massive amounts of sunlight into electrical and then chemical energy. The input is carbon dioxide (CO<sub>2</sub>), water (H<sub>2</sub>O), and sunlight. The output is glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>) and oxygen (O<sub>2</sub>).

Video: Photosynthesis

**Photosynthetic Equation**

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A colorless, odorless gas present in the atmosphere and formed when people exhale during respiration.

**Carbon Cycle**

Notebook

**Photosynthetic Equation**

This is a note over the video.

**Key Term: Thylakoids**

A membrane-bound compartment inside chloroplasts and cyanobacteria. They are the site of the light-dependent reactions of photosynthesis.

**Video: Photosynthetic Equation**

**Key Term: Glucose**

Glucose as produced by green plants during the photosynthesis process is used as the main source of energy for a plant and also as a metabolic intermediate. Glucose is first turned into starch for it to be used as an energy store.

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**A leaf may be viewed as a solar collector crammed full of photosynthetic cells.**

### 11.3 Appendix C: Steps required to complete KLM tasks

Tasks	Interaction Patterns & KLM Operators	
	<i>SMART Note</i>	<i>Inkling</i>
<b>Task 1.</b> Highlight a sentence.	<b><i>One-tap highlighting</i></b> 1. Read the sentence (M=7.6s) 2. Tap any part of sentence (P+B=0.6s)	<b><i>Tap-and-swipe highlighting</i></b> 1. Read sentence (M=7.6s) 2. Tap & hold & activate highlight commands (P/H=1.0s) 3. Swipe right to select full sentence (D=3.6s)
<b>Task 2.</b> Save a key term and definition for future review.	<b><i>Key term capture</i></b> 1. Tap key term to see popup (P+B=0.6s) 2. Read definition (M=7.5s) 3. Decide to add definition to notebook (M=1.2s) 4. Tap “+” button (P+B=0.6s) 5. Tap page to close popup window (P+B=0.6s)	<b><i>Manual key term entry</i></b> 1. Tap key term to see popup (P+B=0.6s) 2. Read definition (M=7.5s) 3. Decide to add definition to notebook (M=1.2s) 4. Swipe page so key term popup is visible (S=2.0s) 5. Tap annotate button (P+B=0.6s) 6. Tap <i>Add a Note</i> (P+B=0.6s) 7. Position hands on keyboard (H=0.4s) 8. Type key term & definition (147K=29.4s) 9. Tap <i>Post</i> (P+B=0.6s) 10. Tap page to close popup window (P+B=0.6s)
<b>Task 3.</b> Save a portion of a video for future review.	<b><i>Video segment capture</i></b> 1. Decide to capture segment (M=1.2s) 2. Tap segment capture button (P+B=0.6s)  <b><i>Review Video Segment</i></b> 1. Tap <i>Videos</i> filter button (P+B=0.6s) 2. Find desired segment (M) 3. Tap desired video segment (P+B=0.6s) 4. Tap play button (P+B+ 30.0s to watch segment=30.6s) 5. Tap <i>Done</i> (P+B=0.6s)	<b><i>Bookmark and manual scrubbing</i></b> 1. Decide to bookmark (M) 2. Tap annotate button (P+B=0.6s) 3. Tap <i>Bookmark</i> (P+B=0.6s) 4. Tap <i>Add a Note</i> (P+B=0.6s) 5. Position hands on keyboard (H) 6. Type time stamp 30s (3K=0.60s) 7. Tap <i>Post</i> (P+B=0.6s)  <b><i>Review Bookmarked Video &amp; Segment</i></b> 1. Tap notebook button (P+B=0.6s) 2. Find desired video bookmark (M) 3. Tap bookmarked video link (P+B=0.6s) 4. Swipe across scrubber to the 30-second starting point (S=2.4s) 5. Tap play button (P+B + 30.0s to watch segment=30.6s) 6. Tap notebook button to return to

		notebook or arrow button to return to book (P+B=0.6s)
<b>Task 4.</b> Save a key term mentioned in a video for future review.	<b>Video key term capture</b> 1. Decide to capture key term (M=1.2s) 2. Tap “+” button when key term appears (P+B=0.6s)	<b>Manual video key term entry</b> 1. Decide to add key term and definition to annotations (M=1.2s) 2. Tap to pause video (P+B=0.6s) 3. Tap annotate button (P+B=0.6s) 4. Tap <i>Add a Note</i> (P+B=0.6s) 5. Position hands on keyboard (H=0.4s) 6. Determine annotation and wording (M=1.2s) 7. Type key term & definition (145K=29s) 8. Tap <i>Post</i> (P+B=0.6s) 9. Tap play button to resume video (P+B=0.6s)
<b>Tasks</b>	<b>Interaction Patterns &amp; KLM Operators–Continued</b>	
	<i>SMART Note</i>	<i>Inkling</i>
<b>Task 5.</b> Add a personalized note to a specific point in the video timeline.	<b>Video point annotation</b> 1. Decide to add annotation to video timeline (M=1.2s) 2. Determine annotation wording (M=1.2s) 3. Tap point annotation button (video pauses) (P+B=0.6s) 4. Position hands on keyboard (H=0.4s) 5. Type annotation (90K=18.0s) 6. Tap <i>Done</i> (video resumes automatically) (P+B=0.6s)	<b>Manual time stamp</b> 1. Decide to add note to video timeline (M=1.2s) 2. Determine annotation wording (M=1.2s) 3. Tap pause button (P+B=0.6s) 4. Tap annotate button (P+B=0.6s) 5. Tap <i>Add a Note</i> (P+B=0.6s) 6. Position hands on keyboard (H=0.4s) 7. Type time stamp: 0:48 (4K=1.0s) 8. Type annotation (90K=18.0s) 9. Tap <i>Post</i> (P+B=0.6s) 10. Tap play button to resume video (P+B=0.6s)
<b>Task 6.</b> Save a sentence from audio to the tablet notebook and attach a personalized note to it.	<b>Video transcript annotation</b> 1. Decide to highlight (M=1.2s) 2. Tap any part of sentence to highlight (P+B=0.6s) 3. Decide to add personalized annotation (M=1.2s) 4. Tap <i>Add Note</i> to pause video (P+B=0.6s) 5. Position hands on keyboard (H=0.4s)	<b>Manual transcription</b> 1. Decide transcribe sentence from accompanying audio (M=1.2s) 2. Memorize sentence for transcription (M=1.2s) 3. Tap video to see control panel (P+B=0.6s) 4. Tap pause button to stop video (P+B=0.6s) 5. Tap annotate button (P+B=0.6s)

	6. Determine annotation wording (M=1.2s) 7. Type annotation (42K=8.4s) 8. Tap <i>Done</i> (video resumes automatically) (P+B=0.6s)	6. Tap <i>Add a Note</i> (P+B=0.6s) 7. Position hands on keyboard (H=0.4s) 8. Type transcription (100K=20.0s) 9. Decide to add personalized annotation (M=1.2s) 10. Determine annotation wording (M=1.2s) 11. Type annotation (42K=8.4s) 12. Tap <i>Post</i> (P+B=0.6s) 13. Tap video to see control panel (P+B=0.6s) 14. Tap play button to resume video (P+B=0.6s)
<b>Task 7.</b> Add personalized note to a static image.	<b><i>Image capture and annotation</i></b> 1. Decide to annotation image (M=1.2s) 2. Tap “+” button (P+B=0.6s) 3. Position hands on keyboard (H=0.4s) 4. Determine annotation wording (M=1.2s) 5. Type annotation (K=11.6s) 6. Tap <i>Done</i> (P+B=0.6s)	<b><i>Image annotation</i></b> 1. Decide to annotate image (M=1.2s) 2. Tap “+” button (P+B=0.6s) 3. Tap annotate button (P+B=0.6s) 4. Tap <i>Add a Note</i> (P+B=0.6s) 5. Position hands on keyboard (H=0.4s) 6. Determine annotation wording (M=1.2s) 7. Type annotation (K=11.6 s) 8. Tap <i>Post</i> button (P+B=0.6s) 9. Tap return to book button (P+B=0.6s)



#### 11.4 Appendix D: Question Appraisal System (QAS-99) coding form

**Instructions for the Reviewer:** Proceed through the form - Circle or highlight YES or NO for each Problem Type. Whenever a YES is indicated, write detailed notes on this form that describe the problem.

**TASK ONE:** Look for problems with any introductions, instructions, or explanations from the respondent's point of view.

<b>CONFLICTING OR INACCURATE INSTRUCTIONS,</b> introductions, or explanations. <b>IF YES,</b> describe the problem:	YES    NO
<b>COMPLICATED INSTRUCTIONS,</b> introductions, or explanations. <b>IF YES,</b> describe the problem:	YES    NO

**TASK TWO:** Identify problems related to communicating the intent or meaning of the questions to the respondent.

<b>WORDING:</b> Are any items lengthy, awkward, ungrammatical, or do any contain complicated syntax? <b>IF YES,</b> indicate which item(s) is problematic and describe the problem(s):	YES    NO
<b>TECHNICAL TERM(S)</b> are undefined, unclear, or complex. <b>IF YES,</b> indicate which item(s) is problematic and describe the problem(s):	YES    NO
<b>VAGUE:</b> There are multiple ways to interpret an item(s) or to decide what is to be included or excluded. <b>IF YES,</b> indicate which item(s) is problematic and describe the problem(s):	YES    NO
<b>REFERENCE POINTS</b> are missing, not well specified, or in conflict. <b>IF YES,</b> indicate which item(s) is problematic and describe the problem(s):	YES    NO

**TASK THREE:** Determine if there are problems with assumptions made or the underlying logic.

<b>INAPPROPRIATE ASSUMPTIONS</b> are made about the respondent or about his/her life.  <b>IF YES</b> , indicate which item(s) is problematic and describe the problem(s):	YES    NO
<b>ASSUMES CONSTANT BEHAVIOR</b> for situations that vary.  <b>IF YES</b> , indicate which item(s) is problematic and describe the problem(s):	YES    NO
<b>DOUBLE-BARRELED.</b> Contains more than one implicit question.  <b>IF YES</b> , indicate which item(s) is problematic and describe the problem(s):	YES    NO

**TASK FOUR:** Check whether respondents are likely to not know or have trouble remembering information.

<b>KNOWLEDGE</b> may not exist: Respondent is unlikely to know the answer to a factual question.  <b>IF YES</b> , indicate which item(s) is problematic and describe the problem(s):	YES    NO
<b>ATTITUDE</b> may not exist: Respondent is unlikely to have formed the attitude being asked about.  <b>IF YES</b> , indicate which item(s) is problematic and describe the problem(s):	YES    NO
<b>RECALL</b> failure: Respondent may not remember the information asked for.  <b>IF YES</b> , indicate which item(s) is problematic and describe the problem(s):	YES    NO

<p><b>COMPUTATION</b> problem: The item(s) requires a difficult mental calculation.</p> <p><b>IF YES</b>, indicate which item(s) is problematic and describe the problem(s):</p>	<p>YES    NO</p>
--	------------------

**TASK FIVE:** Assess items for sensitive nature or wording, and for bias.

<p><b>SENSITIVE CONTENT</b> (general): The question asks about a topic that is embarrassing, very private, or that involves illegal behavior.</p> <p><b>IF YES</b>, indicate which item(s) is problematic and describe the problem(s):</p>	<p>YES    NO</p>
<p><b>SENSITIVE WORDING</b> (specific): Given that the general topic is sensitive, the wording should be improved to minimize sensitivity.</p> <p><b>IF YES</b>, indicate which item(s) is problematic and describe the problem(s):</p>	<p>YES    NO</p>
<p><b>SOCIALLY ACCEPTABLE</b> response is implied by the question.</p> <p><b>IF YES</b>, indicate which item(s) is problematic and describe the problem(s):</p>	<p>YES    NO</p>

**TASK SIX:** Assess the adequacy of the range of responses to be recorded.

<p><b>MISMATCH</b> between question and response categories.</p> <p><b>IF YES</b>, describe the problem:</p>	<p>NO    YES</p>
<p><b>TECHNICAL TERM(S)</b> are undefined, unclear, or complex.</p> <p><b>IF YES</b>, describe the problem:</p>	<p>NO    YES</p>
<p><b>VAGUE</b> response categories are subject to multiple interpretations.</p> <p><b>IF YES</b>, describe the problem:</p>	<p>NO    YES</p>

<b>OVERLAPPING</b> response categories. <b>IF YES</b> , describe the problem:	NO      YES
<b>MISSING</b> eligible responses in response categories. <b>IF YES</b> , describe the problem:	NO      YES
<b>ILLOGICAL ORDER</b> of response categories. <b>IF YES</b> , describe the problem:	NO      YES

**TASK SEVEN:** Look for problems not identified in Tasks 1-6.

Detail other problems not previously identified below:

## 11.5 Appendix E: Active Reading Experience Questionnaire (AREQ)

### Active Reading Experience Questionnaire Items

Please indicate your level of agreement with how well this tool supported you in the following active reading goals.

		1	2	3	4	5	6	7	N/A
<b>Technology</b>									
Take general notes (not in the form of a structured outline)	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Take notes on a digital device (i.e., laptop, smartphone, tablet)	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Mark parts of a video (i.e., make note of a specific point in the video timeline so you can add a note to it or easily find that point in the video later)	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Save portions of a video	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Take notes over video content	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Record audio notes	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
<b>Purpose</b>									
Comprehend what I read or watch (for example, be able to answer questions about it and discuss topics in my own words)	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Memorize parts of the educational material	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Search for a specific piece of information	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Analyze the educational material for accuracy	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Evaluate educational material to form my own opinion	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Synthesize what I read or watched (i.e., combine information to see how it all fits together)	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Understand the author's purpose	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Understand the structure of the educational material	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Understand the author's stance	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
<b>Physical Strategies</b>									
Highlight text	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Make notes of key terms	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Organize annotations (i.e., notes) into a different format	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Test myself over the information	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Rank my annotations (i.e., notes) in order of importance	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Summarize educational material in my own words	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Mark main ideas	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Create a practice test	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Make an outline of the material	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Make a flow chart of the material	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Make note cards	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Survey each chapter by reading the introductory and concluding paragraphs, headings, subheadings, visual captions, review questions, etc.	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Make study questions	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Cross-reference information from lecture notes and information from the assigned educational materials	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>
Orally recite what I've read or watched after each section/main topic	strongly disagree	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	strongly agree <input type="checkbox"/>

## 11.6 Appendix F: National Aeronautics Space Administration-Task Load Index (NASA-TLX)

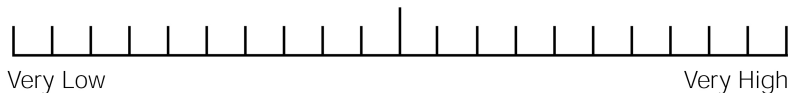
Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

**This survey is meant to measure your perceptions about the active reading experience, not the Photosynthesis chapter. So answer these questions in light of your thoughts about the note taking experience, not the difficulty of the material itself.**

Name	Task	Date
------	------	------

Mental Demand

How mentally demanding was the task?



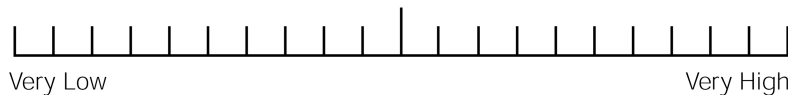
Physical Demand

How physically demanding was the task?



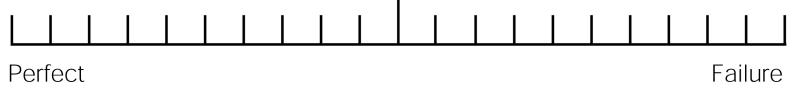
Temporal Demand

How hurried or rushed was the pace of the task?



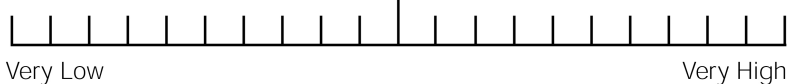
Performance

How successful were you in accomplishing what you were asked to do?



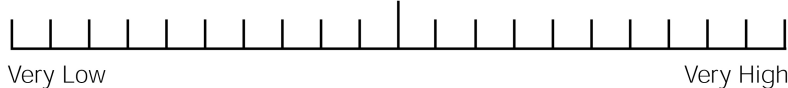
Effort

How hard did you have to work to accomplish your level of performance?



Frustration

How insecure, discouraged, irritated, stressed, and annoyed were you?



### 11.7 Appendix G: System Usability Scale (SUS)

**Instructions:** For each of the following statements, mark one box that best describes your reactions to the system you engaged with today.

	5 Strongly Agree	4 Agree	3 Neutral	2 Disagree	5 Strongly Disagree
I think that I would like to use this system frequently.					
I found the system unnecessarily complex.					
I thought the system was easy to use.					
I think that I would need the support of a technical person to be able to use this system.					
I found the various functions in this system were well integrated.					
I thought there was too much inconsistency in this system.					
I would imagine that most people would learn to use this system very quickly.					
I found the system very cumbersome to use.					
I felt very confident using the system.					
I needed to learn a lot of things before I could get going with this system.					

**Please provide any comments about the system:**

## 11.8 Appendix H: Feature-level utility rating questionnaires

### 11.8.1 SMART Note questionnaire

<b>I found the following annotation features useful:</b>	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
One-tap highlighting					
Key term capture					
Video key term capture					
Video transcript annotation/highlighting					
Video point annotation					
Video segment capture					
Image capture & annotation					
General note taking					
Annotation notebook					

<b>I found the following features easy to use:</b>	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
One-tap highlighting					
Key term capture					
Video key term capture					
Video transcript annotation/highlighting					
Video point annotation					
Video segment capture					
Image capture & annotation					
General note taking					
Annotation notebook					

<b>I would regularly use the following annotation features:</b>	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
One-tap highlighting					
Key term capture					
Video key term capture					
Video transcript annotation/highlighting					
Video point annotation					
Video segment capture					
Image capture & annotation					
General note taking					
Annotation notebook					



### 11.8.2 Baseline prototype questionnaire

<b>I found the following annotation features useful:</b>	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
Tap and drag highlighting					
Key term pop ups					
Video annotation					
General note taking					
Page bookmarking					
Annotation notebook					

<b>I found the following features easy to use:</b>	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
Tap and drag highlighting					
Key term pop ups					
Video annotation					
General note taking					
Page bookmarking					
Annotation notebook					

<b>I would regularly use the following annotation features:</b>	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
Tap and drag highlighting					
Key term pop ups					
Video annotation					
General note taking					
Page bookmarking					
Annotation notebook					

## **11.9 Appendix I: Comparative study quiz**

### ***11.9.1 Short answer questions***

Answer the following questions as thoroughly as you can. Feel free to draw pictures on the accompanying sheet of paper to correspond with your answers if you like.

1. Explain the process of photosynthesis.
2. Explain the chemical conversion that occurs during photosynthesis by writing the photosynthetic equation.
3. Explain the carbon cycle.
4. In general, describe how the structure of a leaf aids in photosynthesis.
5. Explain how the nature of light factors into the photosynthetic process.
6. Explain how and why leaves change color.

### 11.9.2 Key term matching questions

Match each key term with its definition.

- |                        |  |
|------------------------|--|
| a. solar energy        | _____ A coenzyme used in anabolic reactions as a reducing agent.   |
| b. plant biotechnology | _____ Membrane-bound organelles found in most cells that make up plants, animals, fungi and many other forms of life.                                    |
| c. phloem              | _____ The result of the process by which radiant light and heat from the sun are harnessed.  |
| d. palisade parenchyma | _____ A fluid that contains stacks (grana) of thylakoids, which are the site of photosynthesis.  |
| e. chloroplast         | _____ A measure of the distance between repetitions of a shape feature such as peaks, valleys, or zero-crossings.  |
| f. NADPH               | _____ Photosynthetic cells that contain thousands of chloroplasts and lie between the upper and lower epidermis layers of a leaf.                        |
| g. mitochondria        | _____ A type of transport tissue in vascular plants that distributes the products of photosynthesis and a variety of other solutes throughout the plant. |
| h. wavelength          | _____ Techniques used to adapt plants for specific needs or opportunities.   |
| i. stroma              | _____ Organelles that contains chlorophyll and other pigments, occurring in plants and algae that carry out photosynthesis.                              |
| j. mesophyll           | _____ Closely spaced, columnar cells located beneath the upper epidermis that are rich in chloroplasts.  |

### **11.10 Appendix J: Comparative study semi-structured interview questions**

1. Overall, how would you describe your experience with the prototype today?
2. How would you describe the process of highlighting and then reviewing text?
3. How would you describe the process of annotating and reviewing key terms?
4. How would you describe the processes of annotating and then reviewing video?
5. Overall, how would you describe your experience with the notebook?
6. What were the main strengths of this system?
7. What were the main weaknesses of this system?

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## **Curriculum Vitae**

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**Supporting Areas of Emphasis:** Communication Studies

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Master of Arts, Ball State University Department of English, 2004

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**Thesis:** *Bridging the Gap Between Visual Rhetoric and Newspaper Design: A Case Study*

Bachelor of Science, Ball State University, Department of Journalism, 1996

**Majors:** Journalism, Graphics & News-Editorial

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### **Professional Employment**

May 1999 – July 2001

Deputy design editor, *Chicago Sun-Times*

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August 1998 – July 2001

Adjunct instructor, graphic design, International Academy for Merchandising and Design

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October 1996 – May 1999

Business art director, *Detroit Free-Press*

News designer, *Detroit Free-Press*

*Detroit, Michigan*

May 1996 – October 1996

Design intern, Knight-Ridder, Inc.

*Detroit, Michigan*

## **Field(s) of Specialization**

Human-computer interaction, user experience design, usability  
Interaction design, graphics reporting, news design, art direction, redesign, animation  
Multimedia storytelling, digital publishing, information visualization, visual rhetoric  
Active reading, educational multimedia, collaborative teaching & learning, blended learning

## **Teaching Philosophy**

Teaching and research are equally important roles in the Department of Journalism. I am deeply committed to collaborative, interdisciplinary teaching and learning, and I believe it is important to serve as a leader in the department's immersive learning efforts. As journalism graphics sequence coordinator, I teach upper level courses in information graphics reporting, interaction design and multimedia storytelling and lead our nationally recognized program. I help make curriculum decisions for the sequence and department; serve the department, college and university on various committees; and work directly with students to help them obtain internships and jobs in visual journalism. I am also the director of the Digital Publishing Studio, which provides students with opportunities to work on cutting-edge projects focused on interaction design and development.

## **Publications and Presented Creative Endeavors**

### **Refereed publications**

George-Palilonis, J. & Bolchini, D. (forthcoming). Active reading behaviors in tablet-based learning. Accepted for publication in the *Journal of Educational Multimedia and Hypermedia*.

George-Palilonis, J. & Butler, D. (forthcoming). Active Reading Experience Questionnaire: Development and validation of an instrument for studying active reading activities. Accepted for publication in the *Journal of Interactive Learning Research*.

George-Palilonis, J. & Bolchini, D. (2014). SMART Note: Student-centered active reading tools for tablet textbooks. *Design, User Experience and Usability – Lecture Notes in Computer Science* 8519, 217-229.

George-Palilonis, J., Butler, D. & Leidig-Farmen, P. (2013). Design Interactive: A nonlinear, multimedia approach for teaching introduction to visual communication and principles of design. *Journal of Educational Multimedia & Hypermedia* 22 (1), 335-351.

Rohani, R., George-Palilonis, P. & Bolchini, D. (2013). Mobile web browsing with aural flows: An exploratory study. *International Journal of Human-Computer Interaction (IJHCI)* 29 (11), 717-742.

Spillman, M. & George-Palilonis, J. (2013). Storytelling with interactive graphics: An analysis of editors' attitudes and practices. *Visual Communication Quarterly* 20 (1), 20-27.

George-Palilonis, J. & King, B. (2012). A framework for authoring interactive, tablet-based books: Multimedia textbooks and multiplatform storytelling. *International Journal of the Book* 10 (1), 19-28.

George-Palilonis, J., Butler, D. & Leidig-Farmen, P. (2011). Design Interactive: A nonlinear, multimedia approach for teaching introduction to visual communication and principles of design. In *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2011* (pp. 128-135). Chesapeake, VA: AACE.

George-Palilonis, J. & Spillman, M. (2011). Interactive Graphics Development (IGD): A framework for studying innovative visual story forms. *Visual Communication Quarterly* 18 (3), 167-177.

George-Palilonis, J. (2010). Research informed design exercises enhance audience understanding among visual communications students. *Journalism & Mass Communication Educator* 64 (4), 414-429.

George-Palilonis, J. & Filak, V. (2010). Visuals, path control, and knowledge gain: Variables that affect students' approval and enjoyment of a multimedia text as a learning tool. *International Journal of E-Learning* 9 (4), 463-480.

George-Palilonis, J., Smith, K., Smith, S. Hanley, M., Tanksale, V. & Flook, C. (2010). Creating smartphone interactive news and advertising content. *The Journal of the International Digital Media and Arts Association* 7 (1), 45-54.

George-Palilonis, J. & Belcher, J. (2009). Visualizing electricity & magnetism: The collaborative development of a multimedia text, a case study. *The International Journal of the Book* 6 (2), 107-114.

George-Palilonis, J. & Filak, V. (2009). Blended learning in the visual communications classroom: Student reflections on a multimedia course. *Electronic Journal of E-Learning*, 7 (3), 247-256.

George-Palilonis, J., Hanley, M. and Tanksale, V. (2009). Research informed design: Process, experience, and results from students and their audiences. *The Journal of the International Digital Media and Arts Association*, 6 (2), 37-47.

Hanley, M., George-Palilonis, J. & Tanksale, V. (2008). Research-informed development for interactive media: Enhancing learning by engaging students with users. *Journal of Interactive Advertising* 9 (1), <http://jiad.org/article110.html>.

George-Palilonis, J. & King, J.B. (2007). The Ball State Digital Publishing Project: An experimental approach to the future of the book. *The International Journal of the Book* 4 (4), 63-70.

## **Books**

George-Palilonis, J. (forthcoming). *A Practical Guide to Graphics Reporting, Second Edition*. Boston: Focal Press.

King, B. & George-Palilonis, J. (forthcoming). *Making Transmedia*. Pittsburgh: Etc. Press.

George-Palilonis, J. *The Multimedia Journalist: Storytelling for Today's Media Landscape*. (2013). Boston: Oxford University Press.

George-Palilonis, J. (2006). *A Practical Guide to Graphics Reporting: Information Graphics for Print, Web and Broadcast*. Boston: Focal Press.

## **Book Chapters**

George-Palilonis, J. (2014). Information Graphics for Multiple Media Formats. In Filak (Ed.), *Convergent Journalism: An Introduction Second Edition*. Boston: Focal Press.

George-Palilonis, J. & Belcher, J. (2010). Harnessing the Power of Visualization to Enhance Learning. In Martin, K. G. & Kalantzis Cope, P. (Eds.), *Emerging Digital Spaces in Contemporary Society - Properties of Technology*. Palgrave Macmillan.

George-Palilonis, J., Hanley, M. & Tanksale, V. (2009). Research Informed Development for Interactive Media: Engaging Students with their Audiences Enhances Learning. In Worley, D. W., et. al. (Eds.), *Best Practices in Experiential and Service Learning in Communication*. Kendall/Hunt Publishing Company.

George-Palilonis, J. (2005). Crossing Platforms: Information Graphics for Multiple Media Formats.” In Quinn & Filak (Eds.), *Convergent Journalism: An Introduction*. Boston: Focal Press.

George-Palilonis, J. (2005). Still Life with Rice: Narrative strategies for empowerment and agency. In Simal (Ed.), *National, Communal and Personal Voices in Asian America and the Asian Diaspora*. Transaction Pub.

## **Multimedia learning modules**

George-Palilonis, J. (2010). *Design Interactive II*. Muncie, Indiana: Vizi Learning Systems.

George-Palilonis, J. & Belcher, J. (2008). *Visualizing Electricity & Magnetism*. Multimedia text at [http://web.mit.edu/viz/EM/flash/E&M\\_Master/E&M.swf](http://web.mit.edu/viz/EM/flash/E&M_Master/E&M.swf)

George-Palilonis, J., Marin-Carle, A. & Leidig-Farmen, P. (2004). *Design Interactive*. Electronic Textbook at <http://jageorge2.iweb.bsu.edu/etextmasters/index.html>

### **Referred Conference Papers & Posters**

George-Palilonis, J. & Bolchini, D. (2014). SMART Note: Student-centered active reading tools for tablet textbooks. Paper presented at the 2014 International Conference on Human-Computer Interaction, Crete, Greece.

Rohani Ghahari, R., George-Palilonis, J. & Bolchini, D. (2014). Combining voice access with aural navigation flows for eyes-free browsing. Poster presented at the 2014 ACM Richard Tapia Celebration of Diversity in Computing, Seattle, Washington.

George-Palilonis, J. & Bolchini, D. (2013). Active reading in the tablet environment: Understanding strategies learners use to study interactive multimedia content. Paper presented at the 11th International Conference on Books & Publishing, Regensburg, Germany.

George-Palilonis, J. & Bolchini, D. (2013). InterActive reading: Understanding strategies learners uses to study multimedia content in tablet-based textbooks. Poster presented at the 2013 IUPUI Research Day, Student Showcase, IUPUI Campus Center, Indianapolis.

George-Palilonis, J. & King, B. (2012). A framework for authoring interactive, tablet-based books: Multimedia textbooks and multiplatform storytelling. Paper presented at the 11th International Conference on the Book, Barcelona, Spain.

George-Palilonis, J., Rohani, R. & Bolchini, D. (2012). ANFORA: Aural navigation flows on rich architectures. Poster presented at the Grace Hopper Celebration of Women in Computing, Baltimore, Maryland.

King, B. & George-Palilonis, J. (2012). 21st Century authors: Multi-platform approaches to interactive storytelling. Paper presented at the Popular Culture Association/American Culture Association National Conference Game Studies Division, Boston, Massachusetts.

Rohani Ghahari, R., George-Palilonis, J. & Bolchini, D. (2012). ANFORA: Aural navigation flows on rich architectures. Poster presented at the 2012 Women in Technology, IUPUI Campus Center, Indianapolis.

Rohani Ghahari, R., George-Palilonis, J. & Bolchini, D. (2012). ANFORA: Aural navigation flows on rich architectures. Poster presented at the 2012 IUPUI Research Day, Student Showcase, IUPUI Campus Center, Indianapolis.



Rohani Ghahari, R., George-Palilonis, J., Moon, S., Archibald, C., Kaser, L. & Bolchini, D. (2012). Eyes-free web browsing with linkless navigation. IUPUI Innovation to Enterprise Showcase & Forum, IUPUI Campus Center, Indianapolis.

Spillman, M. & George-Palilonis, J. (2012). Storytelling with interactive graphics: An analysis of editors' attitudes and practices. Paper presented to the Association for Education in Journalism and Mass Communication, Visual Communication Division, Chicago, Illinois. **Awarded Top Paper in division.**

Bolchini, D., Rohani Ghahari, R. & George-Palilonis, J. (2011). ANFORA: Aural navigation flows on rich architectures. Poster presented at the 2011 World Usability Day, organized by the Indiana Chapter of the Usability Professionals' Association (UPA), Indianapolis.

Bolchini, D., Rohani Ghahari, R. & George-Palilonis, J. (2011). ANFORA: Aural navigation flows on rich architectures. Invited poster presented at the 2011 IUPUI TRIP (Translating Research Into Practice) Showcase, Indianapolis, IUPUI Campus Center.

George-Palilonis, J., Butler, D. & Leidig-Farmen, P. (2011). Design Interactive: A nonlinear, multimedia approach for teaching introduction to visual communication and principles of design. Paper presented at the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, Honolulu, Hawaii.

George-Palilonis, J., Smith, K., Hanley, M., Tanksale, V., Smith, S. & Flook, C. (2010). Enhancing digital content with a multimedia mobile news and advertising application: A case study. Paper presented at the Newspapers & Community-Building Symposium XVI, Omaha, Nebraska.

George-Palilonis, J. & Spillman, M. (2010). Interactive Graphics Development (IGD): A framework for studying innovative visual story forms. Paper presented to the Association for Education in Journalism and Mass Communication, Visual Communication Division, Denver, Colorado. **Awarded third place in division.**

George-Palilonis, J. & Filak, V. (2010). How a multimedia course design affects differing learning styles in the visual communication classroom. Paper presented to the Association for Education in Journalism and Mass Communication, Visual Communication Division, Denver, Colorado.

George-Palilonis, J. (2009). Research informed design exercises enhance audience understanding among visual communications students. Paper presented at the Association for Education in Journalism and Mass Communication Conference, Boston, Massachusetts.

George-Palilonis, J. & Filak, V. (2009). Blended learning in the visual communications classroom: Student reflections on a multimedia course. Paper presented to the International Conference on E-Learning, Toronto, Canada.

George-Palilonis, J., Hanley, M., Smith, S., Flook, C., Tanksale, V. & Smith, K. (2009). Creating smartphone interactive news and advertising content. Paper presented at the iDMAa Conference, Muncie, Indiana.

Hanley, M., Flook, C., George-Palilonis, J., Smith, K., Smith, S. & Tanksale, V. (2009). *iPhone news and advertising application*. Poster presented at the Apple AcademiX 2009 Conference, Indianapolis.

Hanley, M. & George-Palilonis, J. (2009). Research-informed iPhone design: Where students and users meet. Poster presentation at the Great Ideas For Teachers (GIFT) session, Association for Education in Journalism and Mass Communication Conference, Boston, Massachusetts. **Named in Top 25 GIFT ideas**. Published in *The Community College Journalist*, by the Community College Journalism Association, Summer 2009.

Smith, K., Hanley, M., Tanksale, V., George-Palilonis, J., Smith, S. & Flook, C. (2009). *iMedia interactive news, information and advertising interface*. Poster presented at the Software Engineering Research Center Showcase, Purdue University, West Lafayette, Indiana.

Spillman, M. & George-Palilonis, J. (2009). Using interdisciplinary teams to spark journalism innovation in the evolving media landscape. Paper presented at Convergence & Society: The Changing Media Landscape Conference, Reno, Nevada.

Belcher, J., Koleci, C., Dourmashkin, P., Murthy, S. & George-Palilonis, J. (2008). Force Field: Electromagnetism visualizations for introductory physics. Poster presented at the American Association of Physics Teachers annual meeting, Edmonton, Alberta, Canada.

George-Palilonis, J. & Belcher, J. (2008). Visualizing electricity & magnetism: The collaborative development of a multimedia text, a case study. Paper presented at the International Conference on the Book, Washington, D.C.

George-Palilonis, J. & Filak, V. (2008). Visuals, path control, and knowledge gain: Variables that affect students' approval and enjoyment of a multimedia text as a learning tool. Paper presented to the Association for Education in Journalism and Mass Communication, Chicago, Illinois.

George-Palilonis, J., Hanley, M. & Tanksale, V. (2008). Research informed design: Process, experience and results from students and their audiences. Paper presented at the International Design and Media Arts Association Conference, Savannah, Georgia.

George-Palilonis, J., Tanksale, V. & Dailey, J. C. (2007). Collaboration and convergence: Merging diverse content in the interdisciplinary classroom. Paper presented at the Convergence and Society: Media Ownership, Control and Consolidation conference, Columbia, South Carolina.

George-Palilonis, J. & King, J.B. (2006). A practical guide to developing and distributing multiple media texts. Presented at the 4<sup>th</sup> Annual International Conference on the Book, Boston.

Smith, K., George-Palilonis J., Leidig-Farmen P. & Popovich, M.N. (2005). Newsroom attitudes toward the roles of newspaper designers. Paper presented to Visual Communications Division for the annual meeting of the AEJMC, San Antonio, Texas.

Demo, L. & George-Palilonis, J. (2003). Convergence and hoops: Basketball is the story and convergence sells it in Indiana. Paper presented at the Society for Professional Journalists Conference, Tampa, Florida.

Herron, M. & George-Palilonis, J. (2003). Finding the right converged journalist: Survey of media professionals keying into the right match. Paper presented at the Society for Professional Journalists Conference, Tampa, Florida

Pritchard, R. & George-Palilonis, J. (2003). Integrating editorial presentation and public relations publications: New frontiers for convergence and collaborative learning. Paper presented at the Association for Education in Mass Communications and Journalism conference, Toronto, Canada. **Awarded third place in division.**

### **Refereed creative endeavors**

George-Palilonis, J., Hopkins, K., Wairanowski, R. and Espinoza, E. (2015). BSU Athletics App. Creative project presented at the Broadcast Education Association, Festival of Media Arts Interactive Multimedia. Las Vegas, Nevada. **Best of Festival award, Interactive Multimedia.**

George-Palilonis, J. (2014). BSU Volleyball app. Creative project presented at the Association for Education in Journalism and Mass Communication, Best of the Web Division, Multiple Class or Institutional App Projects Mobile App Design in the Service of Storytelling (rewarding elegance in interactive design with Apps). Montreal, Canada. **First Place award.**

George-Palilonis, J., Young, L. Taylor, C., Kartman, A. (2014). Sports Link app. Creative project presented at the Association for Education in Journalism and Mass Communication, Best of the Web Division, Multiple Class or Institutional App Projects Mobile App Design in the Service of Storytelling (rewarding elegance in interactive design with Apps). Montreal, Canada. **Second Place award.**

Kuban, A. & George-Palilonis, J. (2014). Police + Press app. Creative project presented at the Association for Education in Journalism and Mass Communication, Best of the Web Division, Individual and Single-class App projects Mobile App Design in the Service of Storytelling (rewarding elegance in interactive design with Apps). Montreal, Canada. **Third Place award.**

King, J.B. & George-Palilonis, J. (2013). Transmedia Indiana: Interdisciplinary, cross-platform multimedia storytelling. Creative project presented at the Association for Education in Journalism and Mass Communication, Creative Projects Division, Washington, D.C. **Honorable Mention award.**

George-Palilonis, J. (2012). *Design Interactive II*. Creative project presented at the Broadcast Education Association Media Arts Festival, Las Vegas, Nevada. **Award of Excellence.**

George-Palilonis, J. & King, J.B. (2010). How seven days in the cold, rain, and mud changed a community. Creative project presented at the Association for Education in Journalism and Mass Communication, Creative Projects Division, Denver, Colorado.

George-Palilonis, J., & Belcher, J. (2008). Visualizing Electricity & Magnetism ([http://web.mit.edu/viz/EM/flash/E&M\\_Master/E&M.swf](http://web.mit.edu/viz/EM/flash/E&M_Master/E&M.swf)). Interactive learning module presented at the Course, Curriculum, and Laboratory Improvement Conference, Boston, Massachusetts.

George-Palilonis, J. (2008). Information graphics and education: Multimedia storytelling, teaching and learning. Presented to the Association for Education in Journalism and Mass Communication, Creative Projects Division, Chicago, Illinois. **Award Winner.**

George-Palilonis, J. & Belcher, J. (2008). Visualizing Electricity & Magnetism ([http://web.mit.edu/viz/EM/flash/E&M\\_Master/E&M.swf](http://web.mit.edu/viz/EM/flash/E&M_Master/E&M.swf)). Interactive learning module presented at the American Association of Physics Teachers meeting, Boston, Massachusetts.

George-Palilonis, J., Marin-Carle, A., & Leidig-Farmen, P. (2004). Design Interactive (<http://jageorge2.iweb.bsu.edu/etextmasters/index.html>). Interactive learning module presented at the Association for Education in Journalism and Mass Communication Conference, Creative Projects Division, Toronto, Canada. **Top Creative Project Award Winner.**

### **Invited presentations**

“How New Technologies Can Make You a Better Teacher,” (Panelist). Association for Education in Journalism and Mass Communication Visual Communications Division, Washington, D.C, 2013.

“Teaching Marathon: The Ideal VisCom Curriculum,” (Panelist). Association for Education in Journalism and Mass Communication Visual Communications Division, Washington, D.C, 2013.

“Why All Your Students Must Be Programmers,” (Panelist). Association for Education in Journalism and Mass Communication Visual Communications Division, Washington, D.C, 2013.

“Breaking the Mold: Innovative Ideas for the Future of Journalism,” (Panelist). Association for Education in Journalism and Mass Communication, Visual Communication Division, Denver, Colorado, 2010.

“Data Visualization for Future of Visual Storytelling” (Workshop Instructor). Society for News Design Student Workshop, Denver, 2010.

“One Job – Many Hats: Prepping Students for Careers Requiring Varying Expertise,” (Panelist). Broadcasters Education Association conference, Las Vegas, Nevada, 2010.

“Strategies for Capstone Success,” (Panelist). Association for Education in Journalism and Mass Communication, Magazine Division, Denver, Colorado, 2010.

“The Power of Tablets: How the iPad and Others are Reshaping the Digital Revolution” (Panelist). Poynter Institute for Media Studies, St. Petersburg, Florida, 2010.

“Visual Storytelling & Information Graphics: Using Flash to Create Rich Data Visualizations,” (Instructor). Association for Education in Journalism and Mass Communication Visual Communications Division Preconvention Workshop, Denver, Colorado, 2010.

“Visualizing Electricity & Magnetism: The Collaborative Development of a Multimedia Text,” (Speaker). Horizon Report 2010: Projects in eBooks, Open Content and Augmented Reality Webinar, July 12, 2010.

“How to Design an Infographic,” (Panelist/Moderator). Association for Education in Journalism and Mass Communication Conference, Visual Communication Division, Boston, Massachusetts, 2009.

“iMedia: Delivering Individualized News and Information via Mobile Technology and TV” (Speaker). Emerging Media Initiative Faculty Symposium, Ball State University, Muncie, Indiana.

“Multimedia Getting Stale? Ways to Better Harness the Power of the Web.” (Speaker). Society for News Design Conference, Las Vegas, Nevada, 2008.

“Multimedia Storytelling” (Workshop Instructor). Our Sunday Visitor publishing company, Huntington, Indiana, 2008.

“Designing with Type,” “The Art of the Simple Idea,” “Information Layering & Story Packaging” and “Information Architecture,” (Workshop Instructor). Our Sunday Visitor publishing company, Huntington, Indiana, 2007.

“Multimedia Storytelling.” (Workshop Instructor). *Dayton Daily News*, Dayton, Ohio, Fall 2007, Spring 2008, Fall 2008.

“Effective Infographics: No Staff Too Small, No Budget (or deadline) Too Tight” (Workshop Instructor). Columbia College, Chicago, Illinois, 2006.

“Graphics Reporting.” (Speaker). Journalism Education Association conference, Nashville, Tennessee, 2006.

“Shaping Content for the Future.” (Workshop Instructor). Associated Press Institute, Reston, Virginia, 2006.

“Making a Strong Connection in the Multimedia World” (Panelist). Indiana Associated Press Managing Editors Conference, Fort Wayne, Indiana, 2005.

“The Art of the Simple Idea.” (Workshop Instructor). *The News-Sentinel*, Fort Wayne, Indiana, 2004.

“The Art of the Simple Idea,” “Six Tips for Improving Design and Presentation,” “10 Questions to Ask Before you Redesign.” (Speaker). Catholic Press Association Conference, Washington, D.C., 2004.

“Designing for Readers,” “Redesign and the College Newspaper.” (Speaker). Society for News Design Newspaper Quick Course, Miami, Florida, 2004

“10 Tips for Stronger Presentation” (Speaker). College Fraternity Editors Association Conference, Indianapolis, 2003.

“10 Tips for Stronger Presentation,” “Design Tips for Small Newspapers” (Speaker). Catholic Press Association Conference, Atlanta, Georgia, 2003.

“Tips for Effective and Evocative Graphics and Design” (Speaker). *The Oregonian*, Portland, Oregon, 2003.

Great Lakes Press Association annual workshop (Keynote Speaker). Bowling Green, Ohio, 2001.

### **Funded Grants**

Provost Immersive Learning Grant, Circle of Blue: Led an interdisciplinary team of students in collaboration with circleofblue.org to conduct original multimedia reporting on how climate change is affecting the Great Lakes, Fall 2010. **\$19,000**

Provost Immersive Learning Grant, Transmedia Indiana: Led (with professor Brad King) an interdisciplinary group of students to develop a cross-platform, cross-genre collection of stories about New Harmony, Indiana in collaboration with the Indiana State Museum, Fall 2010. **\$28,000**

Emerging Media Initiative Grant, iMedia: Led (with professors Suzy Smith, Mike Hanley and Vinayak Tanksale) an immersive learning course in which an interdisciplinary group of students created interactive iPad app for Ball State Sports Link, Spring 2010. **\$10,000**

Provost Immersive Learning Grant, iMedia: Smartphone news app research and development, Fall 2008. **\$30,000**

Provost Immersive Learning grant, NewsClick Indiana: Co-taught (with professor Mary Spillman) an interdisciplinary immersive learning course that focused on the development of business plan, marketing strategy and web portal for journalistic games wire service, Fall 2008. **\$16,850**

Center for Media Design Fellowship, Ball State Digital Publishing Project: Ongoing research focused on developing a digital publishing model for multimedia teaching and learning tools, 2006. **\$15,000**

iCommunication Grant, Design Interactive: E-text development grant (with professors Alfredo Marin-Carle and Pamela Leidig-Farmen), 2003. **\$40,000**

iCommunication Grant, Visual Edge workshop travel grant, 2002. **\$1,500**

iCommunication Grant, Travel grant to visit two newspapers and convergent media organizations in Florida to conduct field research in convergent newsrooms. Visit resulted in the *South Florida Sun-Sentinel* "News Illustrated" partnership/project, 2002. **\$2,600**

### **Publication redesigns**

*Maine Townsman* (2014)

*The Philadelphia Inquirer* (2013)

*Georgia Bulletin* (2013)

*Arkansas Catholic* (2010)

*The Andersonian* (2009)

*Our Sunday Visitor* (2009)

*St. Louis Review* (2008)

*Kennebec Journal*, Augusta, Maine (2008)

*Morning Sentinel*, Waterford, Maine (2008)

*The Journal Gazette*, Fort Wayne, Ind. (2007)

*Pittsburgh Catholic* (2007)

*Shepparton News*, Australia (2006)

*Pointe Reyes Light*, Calif. (2006)

College of Communication, Information and Media Style Guide (2006)

*The Northwest Catholic Progress*, Seattle, Wash. (2005)

*El Pregonero*, Washington, D.C. (2004)

*Catholic Standard*, Washington, D.C. (2004)

*El Pueblo Católico*, Denver (2004)  
*Denver Catholic Register* (2004)  
*Crain's Chicago Business* (2004)  
*The Portland Press-Herald*, Maine (2004)  
*International Design & Media Arts Association Journal* (2004)  
*The Catholic Answer*, national magazine (2004)  
*The Harvard Crimson*, Harvard College (2004)  
*The News-Sentinel*, Fort Wayne, Ind. (2004)  
*Our Sunday Visitor*, national Catholic newspaper (2003)  
*North Country Catholic*, Ogdensburg, N.Y. (2003)  
*Dartmouth Life*, Dartmouth College. (2003)  
*The Evangelist*, Albany, N.Y. (2002)  
*Today's Catholic*, Fort Wayne, Ind. (2002)  
*VOX*, Dartmouth College (2001)  
*The BG News*, Bowling Green State University (2000)

### **Awards**

Best of Festival, *BSU Athletics app*, Broadcast Education Association Media Arts Festival, 2015

National Journalism & Mass Communication Teacher of the Year: Charles E. Scripps Award, Scripps Howard Foundation, 2013,  
<http://ballstatejournalism.com/2014/01/12/palilonis-wins-national-journalism-educator-award/>

Ball State Difference Maker of the Month, 2013

MIRA Award for Individual Education Contribution in Technology, Finalist, 2013

Outstanding Teaching Award, Ball State University, 2012

MIRA Award for Individual Education Contribution in Technology (with Brad King), Finalist, 2012

Award of Excellence, *Design Interactive II*, Broadcast Education Association Media Arts Festival, 2012

High Technology Award, College of Communication, Information, and Media, Ball State University, 2011

Distinguished Researcher of the Year, College of Communication, Information, and Media, Ball State University, 2010



MIRA Award for Individual Education Contribution in Technology, Finalist, 2009

AT&T Big Mobile on Campus Challenge First Runner Up (iMedia iPhone advertising and news application developed in iMedia immersive learning course), 2009. Received a \$5,000 grant from AT&T as part of the award. iMedia faculty members donated grant to the iMedia iPhone course for future expenses.

Outstanding Teaching Award Finalist, Ball State University, 2007

Dean's Faculty Award, College of Communication, Information, and Media, Ball State University, 2006

Graduate of the Last Decade (GOLD Award), Ball State University, 2006

Young Alumnus of the Year, Department of Journalism, Ball State University, 2006

Special recognition for "significant academic accomplishments at the graduate level," Ball State University, Department of English/Graduate School, 2004

Professionalism Award, College of Communication, Information, and Media, Ball State University, 2003

Award of Excellence, newspaper redesign, Society for News Design, 2002

Award of Excellence, news design, Society for News Design, 1999

Award of Excellence, breaking news design, Society for News Design, 1999